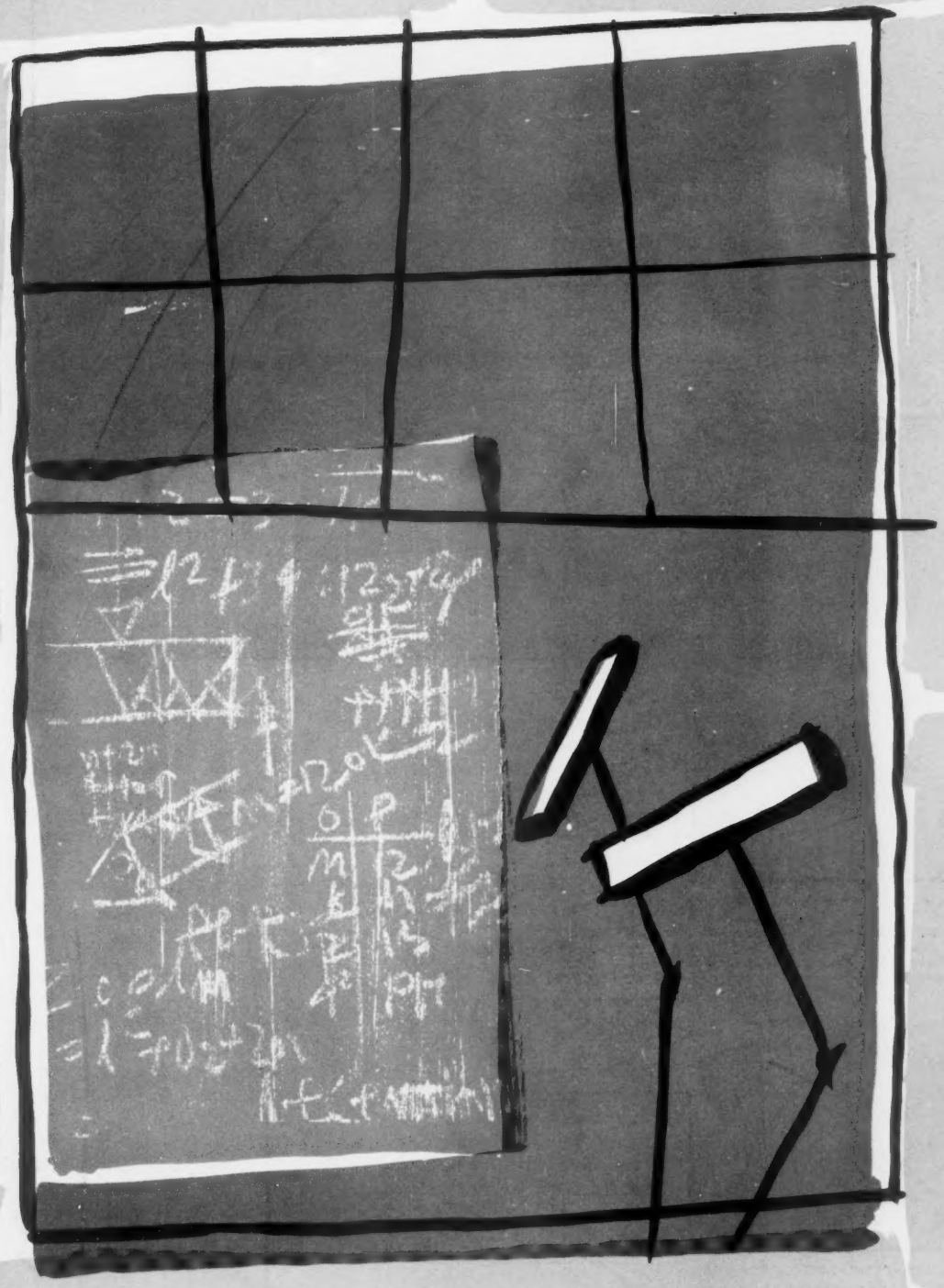
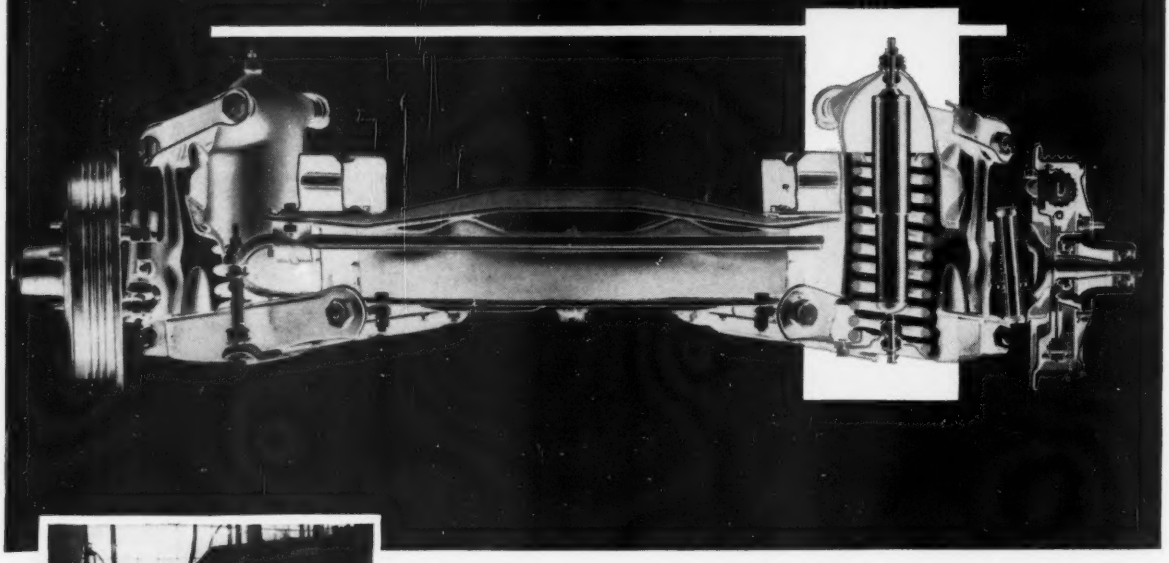
# tech engineering news

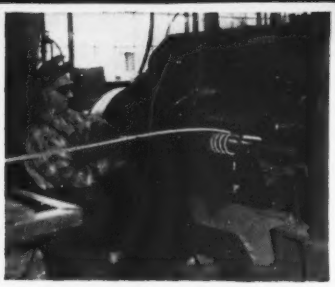


october 1953

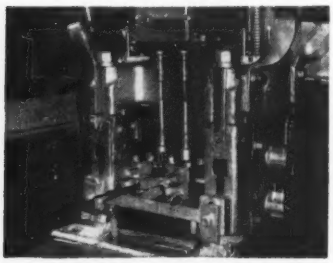
# We gambled on the future

# and the auto industry cashed in





● Here, at Muehlhausen Spring Division of Standard Steel Spring Co., precision-rolled U·S·S CARILLOY Spring Rounds are coiled without centerless grinding. CARILLOY Rounds have minimum decarburization, and they cost less to use.



● At the Gary Works of United States Steel, this precision mill rolls CARILLOY Coil Spring Rounds with extreme accuracy. Tolerances are half of standard: .004″ on the diameter, instead of the usual .008″, and only .006″ out of round, compared to .012″ on ordinary rolled bars.

IN the early days of the development of coil springs for front suspensions of automobiles, the only steel that was available was an ordinary hot-rolled bar from which as much as .035″ of metal per side had to be removed by grinding to insure freedom from harmful seams, pits, and decarburization. This cost money, was wasteful and time consuming.

We at United States Steel felt there was a better way of doing this, so we put our best engineers on the problem.

Using a mill especially equipped for the purpose, they devised an ingenious method of producing hot-rolled bars to eliminate harmful defects and most of the grinding expense. Rolled by this method to half the standard tolerances, with half or less the amount of decarburization, these CARILLOY Precision Rolled Coil Spring Rounds can be used "as furnished" or with only a small amount of centerless grinding.

This exclusive development has paid off in two ways. It has paid off for the automobile manufacturer in that his costs are reduced and spring performance is of the highest order. And it has paid off for us because these CARILLOY Precision Rolled Coil Spring Rounds are now used in over half of the coil springs in new automobiles.

Here's just one more example of the better steel products being developed by United States Steel's vast research program. To keep pace with the ever-increasing demand for special steel, United States Steel is always looking for young men with exceptional ability and training in metallurgy, engineering and related fields. For more information, write United States Steel Corporation, Room 2816-C, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS

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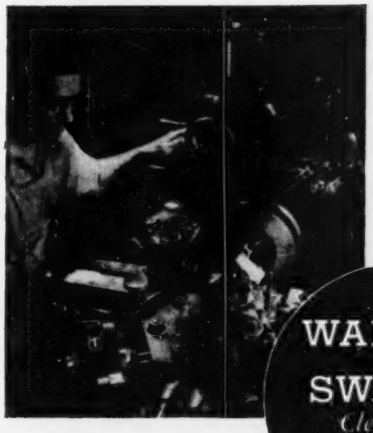
But there *is* a way to enjoy security in America (and only in America, by the way). That is, to make yourself something the world must have—a skillful farmer, a productive worker, a sound businessman. In this country it is true that the more value you add to the world and the more you add to the world's goods, the more you will be paid in return. *That* is security with self-respect —the only kind of security Americans want.



*There are employment opportunities at Warner & Swasey for young men of ability and character who believe as firmly in the principles of Americanism as they do in the principles of sound engineering. Write Charles Ufford.*

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Does the opportunity pay off? Many engineering school graduates, now in key jobs at GM, can testify that it does.

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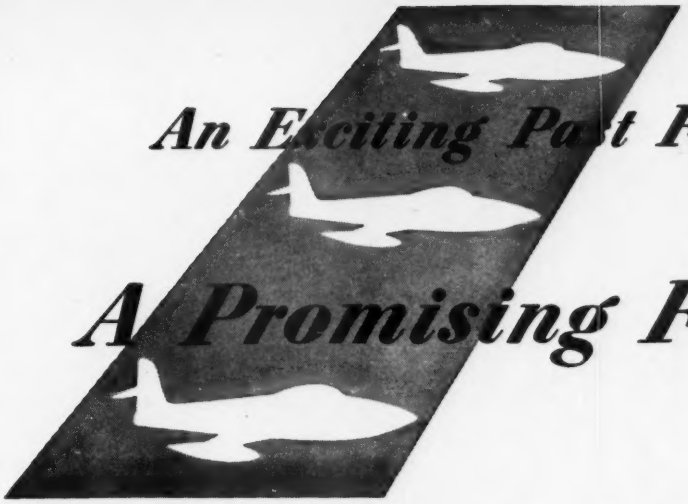

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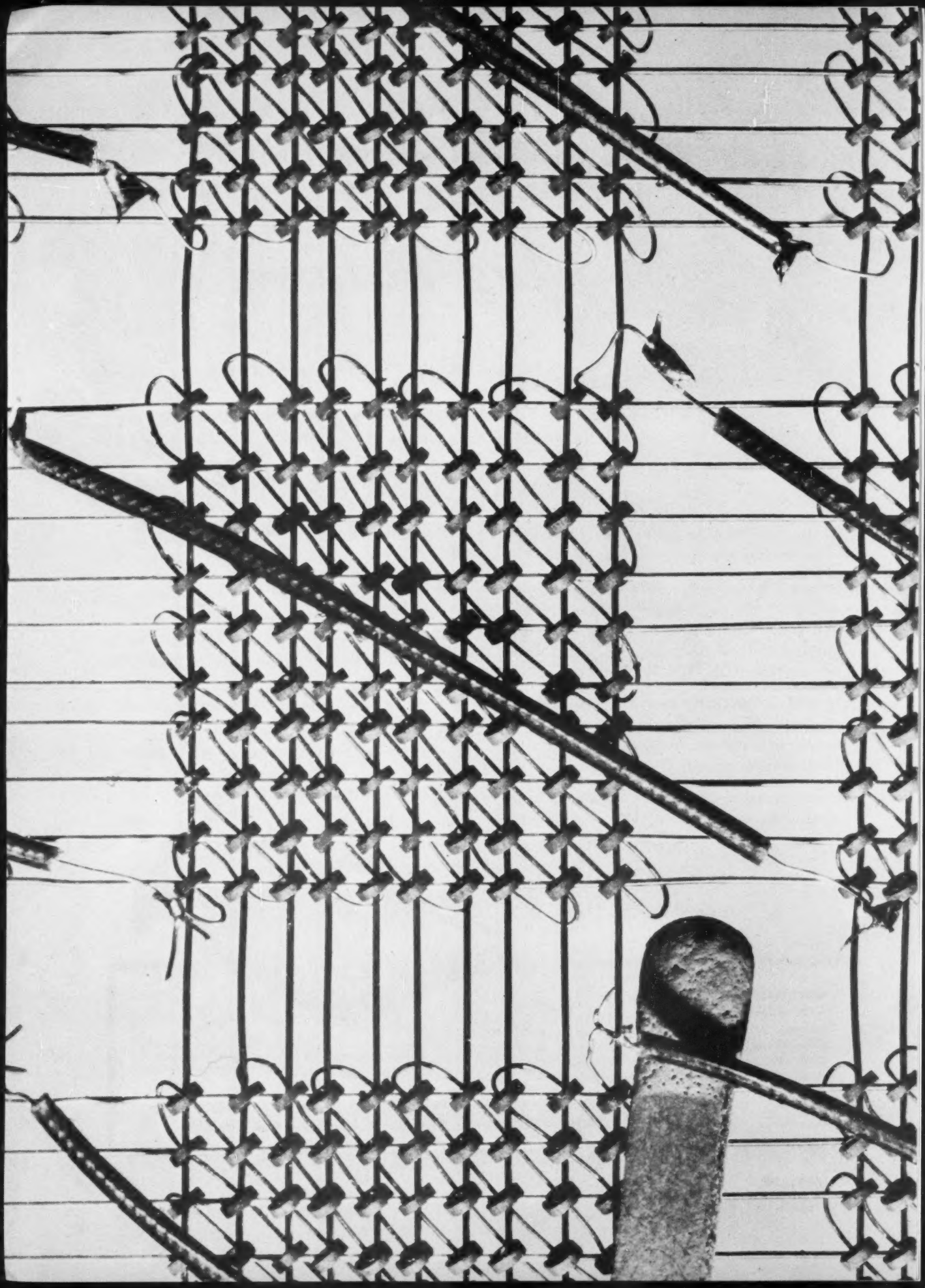

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***FRONTISPIECE***

***Spaghetti Patchwork***

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# How your pipe dreams may become realities!

*Lengths of Republic Electric Weld Casing are rapidly joined together and lowered hundreds or thousands of feet into an oil or gas well to line it with tough steel—to protect its walls against the tremendous pressures that otherwise might cause collapse of the hole.*

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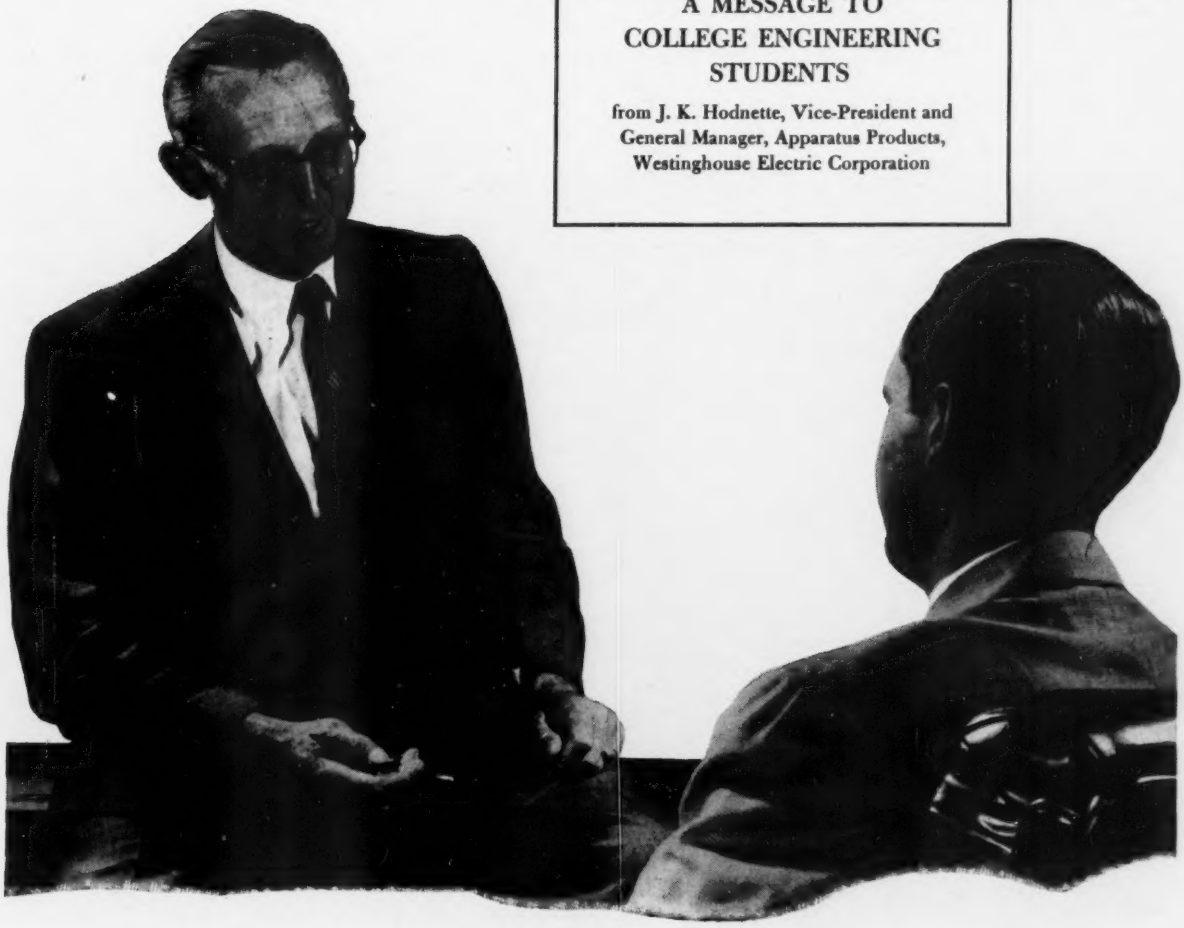
**A MESSAGE TO COLLEGE ENGINEERING STUDENTS**

from J. K. Hodnette, Vice-President and General Manager, Apparatus Products, Westinghouse Electric Corporation



# To the young man with a vision of success

Success means different things to different men. It can mean professional recognition, or great achievement, or exciting work, or many other things. Whatever its special meaning to you—keep its image in your mind, for you are already well on the way to achieving it!

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# education and the freshman

By Dana L. Farnsworth, M.D.

The Class of 1957 is beginning its work at the Institute at a time of great activity in many fields. The role of the scientist and engineer is under discussion and criticism to a constantly increasing degree. The idea that the scientist is responsible only for the search for truth is outmoded. That he is equally concerned with the results of his investigations and how they are used by others is more and more taken for granted. How to develop the ability to be a first-rate scientist on the one hand and an equally good interpreter of the role of technology and science in our society on the other is a question of deep concern to all who are responsible for planning the educational opportunities at M.I.T.

The average Freshman who comes here is filled with enthusiasm and interest. He has known for a long time that he was good in mathematics or physics or chemistry, and studies in this general area were a breeze for him in high school. Perhaps he took pleasure in getting high marks with little apparent effort and certainly he could not resist feeling a sense of pleasure at being called brilliant by his teachers. Maybe he wasn't so good in english or sociology or history, but that was easily passed over with some such thought as, "Well, those subjects are pretty vague and not very important anyway. Besides I'm a slow reader but I could get them easily if I set my mind to it." His beginning tendencies to narrow his point of view, belittling those areas of knowledge he did not understand too well, were easily overlooked in the general excellence of his accomplishments.

Some Freshmen are here because they have been sent by parents who did not realize how much they were influencing their son's or daughter's choice. A few, possible, are here for exactly the opposite reason, to show their parents they can succeed in a tough school. Whatever the varied reasons, the actual shock of suddenly coming into strong competition with 850 other persons with good records and a strong determination to succeed, is greater than most had anticipated. The result may be, and usually is, that the student settles down to work, develops good study habits, becomes a bit less of a perfection-

ist, learns a flexible, realistic way of accepting relative defeats, and finally comes through with satisfaction to himself and his associates.

A very considerable number find the going anything but easy. Having developed the habit of depending on their native intelligence without learning good study habits, they may soon get hopelessly behind in their work. Those who are here primarily because of their parents' insistence find it easy to get even with them by failing. If one's relationships with parents have been unsatisfactory for a long time, some of the same difficulties will come up in relation to faculty members or older students, making it seem as if the Institute were in a sense contributing to the lack of success.

Nostalgia, or plain homesickness, is a big obstacle for several first year men. A few decide to make a really big splurge and sign up for too many extra-curricular activities, getting completely bogged down in a few weeks. A still larger number are so determined to make good that they avoid everything but classes, laboratory and study, thus developing an intolerable sense of loneliness or isolation, boredom, and a feeling that nothing matters much anyway.

The curriculum itself offers the single greatest hazard to a sense of accomplishment the first year or two, and it is at the same time the source of the greatest pride and of the reputation that the school possesses. A favorite comment of undergraduates is that M.I.T. is much over-rated, that it isn't as good as lay people think it is. This was brought out a few years ago in a so-called joke in *Voo Doo*, in which a Freshman was bitterly decrying the ignorance and poor teaching of one of his professors, to which his friend replied, "Yes, and to think that he is the best man in his field." The point is this: it makes no particular difference just now what the reputation of the place is; what is important is whether or not it is possible to get a good education here.

There are two kinds of accomplishments to be gained in a scientific and technological institution. One can become a very skilled technician and do many complicated procedures in a very expert way. Along this path lies much satisfaction and the assurance of a steady income. This kind of training is given at M.I.T. but only incidentally to a larger purpose, even though such skills are necessary to all good scientists and engineers. The Institute is really interested in developing men with a professional point of view, men who (to quote Professor W. K. Lewis) can handle themselves with ease and confidence in new and unfamiliar situations. As Ortega y Gasset pointed out, the vital center of technology is pure science, and our very continuance in the kind of a civilization we live in depends on the activities of men who work and speculate and experiment in fundamental areas of knowledge. The first-year man who wants to become proficient in the professional sense must take the long-term view, be capable of long hours of hard work, develop curiosity and enthusiasm for knowledge for its own sake, and at the same time constantly strive to keep in mind the relation of his own activities to those in other fields of endeavor.

Looked at in this sense, the Institute is not giving him an education. No professional school can or should do that. It is merely attempting to create a special set of circumstances that will enable him to acquire it for himself in the most advantageous manner possible. Someone has said that education is the one commodity for which the buyer tries to make the worst possible bargain. At any rate it does seem clear that many students, through no fault of their own find it difficult to look at themselves objectively and so credit various elements in their environment for their lack of accomplishment. Getting to college is not enough; enthusiasm, idealism, energy, good intellectual habits, wide range of interests, ability to relate to one's fellows, and a sense of humor are even more necessary.

Since it is difficult for the young student to make his interests and tastes develop in line with what his older colleagues believe to be the proper form, it might be worthwhile to look at some of the obstacles to easy, natural development of the ability to enjoy scholastic work. M.I.T. has most of the usual ones possessed by all schools with a few peculiarly its own. The chief one of the latter category is the over-emphasis on the cumulative rating of "cum" as it is locally called.

The system of keeping a cumulative rating on each student has many things to be said in its favor. It enables the student to know just where he stands. Placement officials and representatives of employing companies find it a meaningful figure. It penalizes the "lazy" and irresponsible student and rewards the constant and regular achiever; in other words, it is fair and impartial. The chief trouble is that it has become so over-emphasized that it now is used for far more meanings than it was ever intended to convey. Students and faculty alike over-value it. It fails to recognize that students do not all develop exactly alike. But worst of all, it furthers the implied belief that ends justify means; or to put it another way, getting a good grade takes precedence all too often over obtaining a thorough understanding of subject matter. As Professor Rule has said, if one concentrates on understanding a subject, the grades will take care of themselves, while if one concentrates on grades, learning deteriorates and grades along with it. It is still true, as Emerson said in 1864, "I would have the student know that no cheating, no coaching, no cramming for exhibition or rank, can be of any use. Only simple ability, only honest knowing, has any lasting value."

Another common hazard is that the new student often has not yet "worked through" his relationships with his parents to the point of satisfying independence and hence is still rebellious or over-dependent upon them, or he may have a mixture of these two attitudes (ambivalence). Consequently, when he gets here he may find people or conditions that recall his unpleasant ambivalence toward his parents and so his hostility or anxiety is aroused. He then displaces his feelings toward the Institute or some situation in his environment, blaming his own shortcomings on it, thus delaying his own progress toward maturity. If, in that situation, regulations which were set up to protect him from his own mistakes or procrastination are interpreted by him as punitive in intent, a vicious cycle is set up

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which sometimes requires outside help for its resolution.

One could also mention apparent lack of personal interest by instructors, the peculiar code of students which often interprets sincere efforts of an individual as apple-polishing, over-emphasis of fraternity life or extra-curricular activities, excessive desire for isolation, the manner of proctoring examinations, the similarity of the last year of high school to the first year curriculum—all these may handicap some students, depending on how they interpret specific situations.*

Last but not least, some students seem to believe that the usual laws of hygiene do not apply to them. They know what to do when illness strikes but they know less than nothing about how health is maintained. The simple requirement of eight hours of sleep, a regular balanced diet, regular exercise and recreation—these are thought to be unnecessary and impossible. The wise student will work on ways and means of working effectively within his physiological limits rather than form the habit of living on borrowed time and nervous energy.

The average Freshman at M.I.T. is about 18 years old. That is a convenient time to think of as the attainment of maturity. Physical maturity has nearly always been reached. Emotional maturity is so variable that one can only say that many have it but that some will never obtain it. Intellectual maturity is still many years away, though its chief elements are usually rather clearly defined in under-graduate years. Whatever may have been the attitude of one's associates before coming to college, the one mainly in evidence here is that the individual is completely responsible for himself until he has proved that he cannot use his freedom wisely. Even then, it is the hope of every faculty member that the individual who has temporarily failed to live up to what is expected of him will be helped back to full responsibility, rather than be forced out of the institution.

In a large school it is very easy for a new man to get lost in the mass, to make no new friends, to feel that no one cares for him in any personal way. This impersonal approach can be eliminated if all individuals, both students and staff, maintain a friendly interested manner in their relations with one another. To help in making the most of the intellectual and social opportunities, the Institute has organized a counseling system, made up of both upperclassmen and faculty members. It is the job of the counselor to help the student formulate his problem rather than solve it for him. Likewise he does not usually give direct advice but helps in looking at the various alternatives so that the student may come to his own decision. The counselor serves as a friend, a center of communication, someone who can help the new student find his way around in the complex community that makes up the Institute. He aids in interpreting the customs of the Institute and in understanding its goals and ideals. It is not his job to tell the student what to do, to probe into his private affairs, nor is he obligated to help every student who comes to see him. The student counselor particularly is in a very good position to help the new student avoid making obvious mistakes. At the same time the skillful upperclassman will try to encourage his new colleague without taking away from him in any degree his feeling of responsibility in his school work.

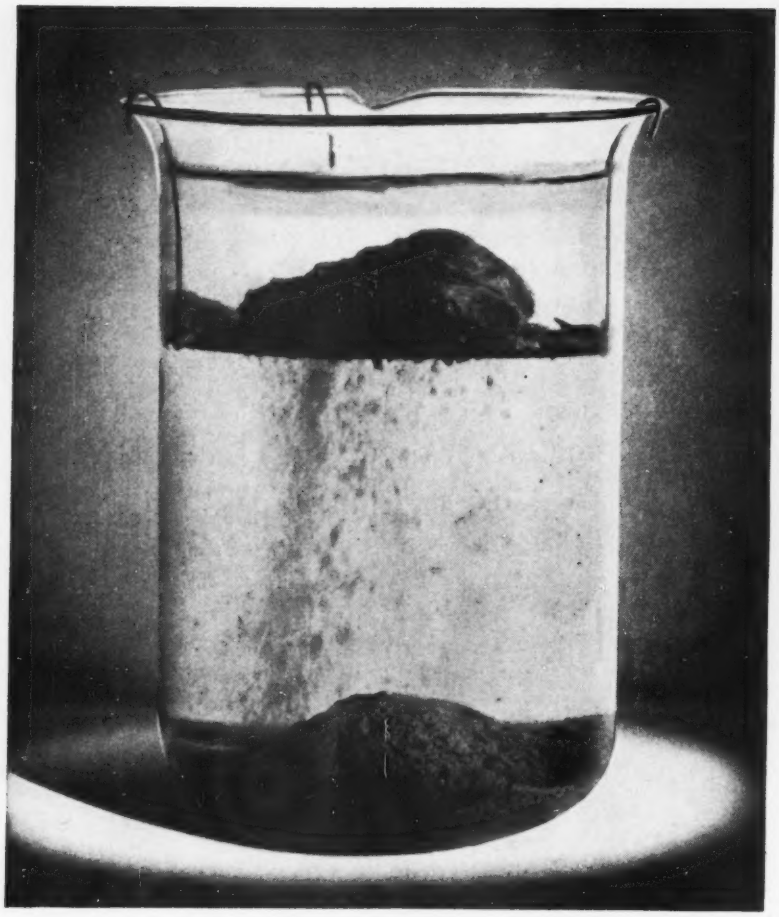
In the counseling system the student has definite responsibilities also. One of these is to get acquainted with his faculty and student counselors as soon as possible. True they are there to help if one is in trouble, but that is only an incidental though important function. They are involved in the system to help the student advance at his own optimum rate and in a manner that will cause him to look back on his years of formal education with keen enjoyment. Consequently every man should make wise use of his counselors, the most capable students particularly.

Counseling may be unofficial as well as official, and it may be unfortunate as well as beneficial. To consider two extremes, an older student may act as a kind of coach, teaching the new men how to outwit the system, who, in his opinion, are the good and the poor teachers, what to gripe about, and in general indoctrinating them in all his dissatisfactions, to which each new man may later add his own. This process is sometimes called "cluing them in." On the contrary, the upperclassman may, and usually has, worked through his own educations experiences to the point that he can realize that the Institute is the result of the combined efforts of thousands of individuals over a period of many years, and is thus in effect a mirror of our best selves in a collective sense. As such it is entitled to respect when the image is clear and desirable, to corrective measures through constructive criticism when some defect appears. A tolerant but friendly critical attitude permits the new student the privilege of making up his own mind about what he sees and experiences, after which he, too, will be in a position to make constructive criticism. In this way true progress may take place. The student who is on the defensive for one reason or another is more apt to criticize first, then think about the issues involved.

A balanced diet in intellectual fare is just as important to the man seeking a sound education as the proper variety of food is to his physical well-being. Most of our students come from homes that have reasonably high standards of conduct, of conversation, of community participation and of culture. In the first flush of excitement that attends the discovery of a new and exciting field of activity, such as science or mathematics, a young man may confine his activities so exclusively to his new interests that he neglects the other necessary ingredients of a general education. As in the physical field, malnutrition then sets in, though gradually and at first imperceptibly. It does come eventually, however, and in all too many instances takes the form of lack of interest in class, seminar or laboratory work, first in the subjects outside of science, then in the very areas in which he had previously been most interested. Grades which had previ-

*(Continued on page 67)*

*Occasionally a student may temporarily exercise poor judgment in relation to his own ability resulting in other students thinking that he is unduly "throwing his weight around."



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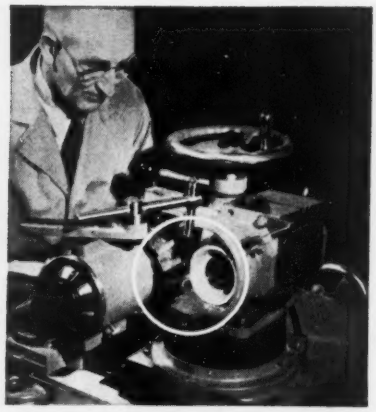

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**says LOWELL E. ACKMANN**

*University of Illinois—B.S., E.E.—1944*
*and now manager, Peoria, Ill., Branch Office*

"MY EXPERIENCE with machinery in the Navy during the war convinced me I needed a training course. There was so much equipment on board that was a complete mystery to me that I became very 'training-course minded'.

"After investigating many training courses, the one at Allis-Chalmers looked best to me then—and still does.

"In my opinion the variety of equipment is what makes Allis-Chalmers such a good training spot.

"No matter what industry you may be interested in, Allis-Chalmers makes important, specialized equipment for that industry. Electric power, steel, cement, paper, rock products, and flour milling industries—to name a few, are big users of A-C equipment.

"Before starting on the Allis-Chalmers Graduate Training Course, I thought I would like selling, preferably technical selling but, as is often the case, I didn't know for sure. This course, together with some personal guidance, helped me make up my mind. That, too, is an important advantage of the GTC program.

"But whether you want to be a salesman or designer, production engineer, or research engineer, Allis-Chalmers, with its wide variety of equipment and jobs, is an ideal place to get off to a good start—without wasting time."

## Facts You Should Know About the Allis-Chalmers Graduate Training Course

**1.** It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

**2.** The course offers a maximum of 24 months' training. Length and type of training is individually planned.

**3.** The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

**4.** He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

**5.** He will have individual attention and guidance in working out his training program.

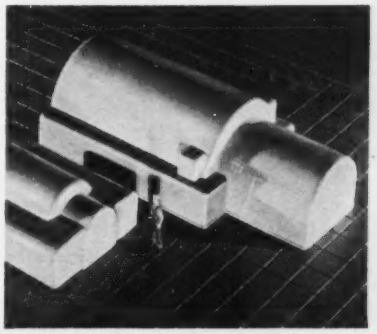
**6.** The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

**7.** For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

**ALLIS-CHALMERS**

C-5676

**PROCESSING**—Allis-Chalmers built solvent extraction plant processes one hundred tons of rice bran per day at oil processing plant in Texas.

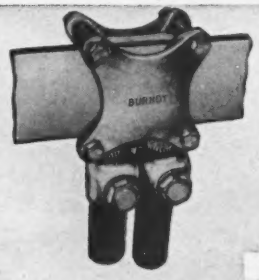


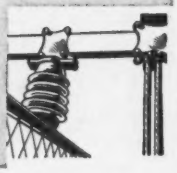
**POWER**—Models show comparative size of generators having the same rating with and without super-charged hydrogen cooling. Allis-Chalmers is first to supply super-charged hydrogen cooling.

# PROBLEM: To join or terminate any electrical conductor—anywhere

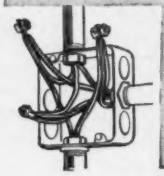
# SOLUTION: BURNDY CONNECTORS

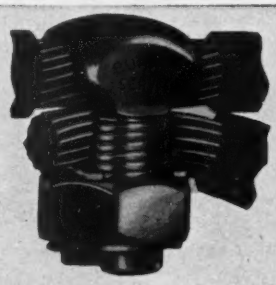
Wherever electrical conductors are joined, terminated, clamped or grounded —you'll find Burndy connectors completing the circuit . . . safeguarding the circuit. Right down the line, from mammoth industrial or utility installations to house service drops . . . from B-36's to washing machines Burndy connectors are included in the most exacting engineering specifications. Wherever your job takes you, you'll find Burndy connectors on the job, too. Here are just a few examples of Burndy-engineered connectors:





**BURNDY BARTAP**
Burndy has developed a complete line of heavy-duty connectors—standard and special shapes—of high current capacity. Used in utility substations, industrial power houses, hydro-electric projects, etc.



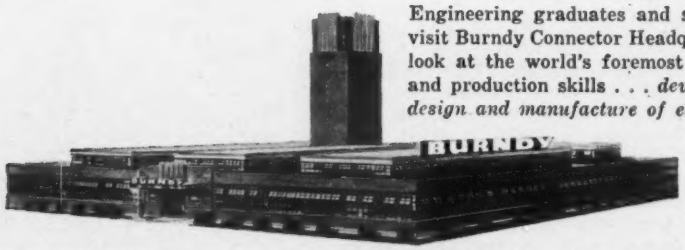


**BURNDY SERVIT**
Most versatile, efficient and popular split-bolt connector for splices, taps, dead-ends. Used and re-used for sizes #12 Str. to 1000 Mcm. Variations available for aluminum and steel conductors, and for combinations of these and copper.

**BURNDY HYSPLICE**
These compression splices, installed by Burndy hydraulic tools, are used in power transmission lines, where joints require maximum conductivity, highest mechanical strength.

**BURNDY HYLUG**
Solderless connector of one-piece, pure copper construction—with longitudinal indent method of installation. Adaptable to economical mass-production, used in thousands of plants manufacturing electrical equipment. *A Burndy exclusive.*

Engineering graduates and students are invited to visit Burndy Connector Headquarters for a first-hand look at the world's foremost research, engineering, and production skills . . . *devoted exclusively to the design and manufacture of electrical connectors.*



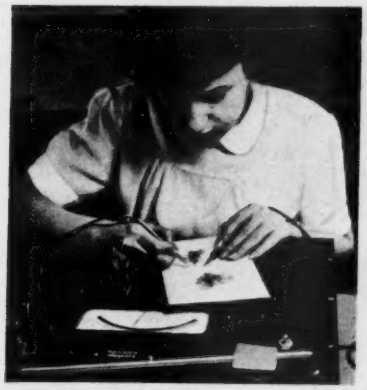

52-25 **BURNDY ENGINEERING COMPANY INC.,** NORWALK, CONNECT. **BURNDY CANADA LTD.,** TORONTO 8, ONT.

# It took 100 years of engineering

**See that tiny speck** of oxide on a hair-like wire? It's called a thermistor, and it's the first practical *thermally* sensitive resistor. It's so sensitive it will measure temperature variations within one-millionth of a degree. As a circuit element and control device, this small, stable and rugged unit has a place in a variety of electrical circuits.

**Although** the thermistor is the smallest and, in appearance, one of the simplest devices made by Western Electric—manufacturing unit of the Bell Telephone System—it was more than 100 years in the making.

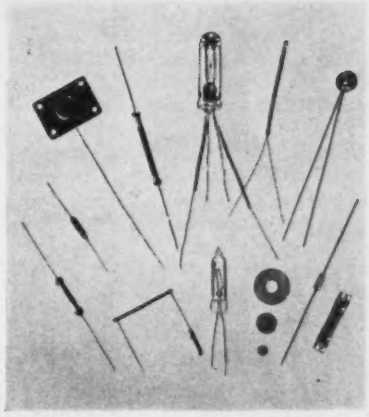
**Back in** the 19th Century—some time before Western Electric was founded in 1869—Michael Faraday studied a curious thermally sensitive resistor material similar to that used in 20th Century thermistors. As Faraday and others after him discovered, the trouble with making effective use of this material was that different units made by what seemed to be the same process, showed large variations in their behavior. The problem of how to control the amount of impurities present in the material was finally solved a few years ago by our research team mates at Bell Telephone Laboratories.



*At Western Electric's Allentown (Pa.) Plant hundreds of minute thermistor components are electrically tested and sorted every day. The basic component, an oxide, has a large negative temperature coefficient of resistivity.*

**Once** beyond the laboratory stage, Western Electric's engineers tackled the job of *mass-producing* the hard-to-handle oxides. After many trials they got a pilot line in operation—then a full scale production line through which compressed powders of thermistor material could be sintered into a strong, compact and homogenous mass. Today reliable thermistors are being made in many shapes and sizes—small beads, rods, discs, washers—to meet varying circuit and design problems. To make this possible, Western Electric engineers had to find new ways to apply a slurry of oxides on wire; new ways to extrude and mold oxide mixtures.

**At every turn,** the thermistor has presented fresh challenges to our engineers. Engineering is like that at Western Electric--where technical men of varied skills pool their knowledge in a constant search for new and better ways to do things.



*The thermistor takes many forms depending on the resistance and power-handling capacity needed in a particular circuit.*

**WANT TO KNOW MORE?**

**Send** the coupon below for a copy of the 16-page technical monograph entitled, "Thermistors as Components Open Product Design Horizons."

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

WESTERN ELECTRIC COMPANY
COLLEGE RELATIONS DEPARTMENT
195 BROADWAY, NEW YORK 7, N. Y.

*I'd like more information about*

☐ Thermistors and their application
☐ Engineering opportunities at Western Electric

Name _____
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City _____ State _____
School _____ Class _____

# tech engineering news

Professional Journal of the Undergraduates of the

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# from the editor's notebook

## On the Weaknesses of Tech Men

One weakness of the Tech man which is often applied as an asset is his utter laziness. Often, in order to avoid getting out of bed on a cold morning to close his window and turn on his radiator, he will work several days to build a system that can perform these tasks automatically for him. The effort that he puts into the building of such a system is far more than the effort that he would have to exert to close a window and turn on a radiator every morning for the rest of his life.

Academically a similar progressive accomplishment is often attained when, falling behind in his work just before a quiz, the Tech man tries to study and learn a subject in as little time as possible. Very often he succeeds! When he succeeds it is a sign that he has applied his laziness to studies and has learned how to study the most in the least time. He learns how to think when he studies and to realize, every moment that he is at his books, just what he is doing and why. He learns to eschew all repetitive "dog work" problems and to work a little more in those fields in which he is having difficulties. When he finally graduates, his most important gain at M.I.T. is not the acquisition of knowledge but the ability to think. He gets the most out of the least, and laziness, accompanied by a little thought, conquers all. Of course, I am not advocating falling behind in one's work. All that I wish to put over is that the Tech man who thinks when he studies gains the most.

This thinking while studying principle should also be applied to the class room. Somebody once said that formal education is a process in which the professor transfers the content of his lecture notes into the note books of the student without having it pass through the brain of either. Too many students go to class with their note books in the role of a stenographer. Everything that is said, even the trivia, is transcribed into the notebooks. At the end of the course the note books are entirely worthless and are usually filed away and never referred to again.

Unfortunately, at M.I.T. there are not many courses which require thinking. Any student who memorizes the text can usually pass the course. Most students, however, do eventually pick up the ability to think; they are lazy and want to make school easier. They do.

D. E.

## Why An Activity?

Much has been said about the advantages of joining an extra-curricular activity —so much that freshmen soon get tired of hearing clichés like "worthwhile experience", "good fellowship", and "better jobs after graduation". We don't deny the existence of these advantages, but for most Tech men they have no real meaning. Most of us join an activity simply because we enjoy it. Of course, the activity or activities anyone selects depends on his personal tastes. Some like to go on winter mountaineering trips and sleep in the snow. Others take pleasure in building model airplanes or amplifiers. Still others feel most at home working for one of the student publications or for our student government.

No matter what you like to do, the important thing to remember is, *do it*. Time should be no problem judging from the many students who are almost always ready to join a bull session or take part in some other activity they enjoy.

H. J.

## About Our Authors . . .

Dr. Hermatilda Klutz, author of *The LeSagian Theory of Gravitation*, is one of the most prominent women in several regions of physical research. She received her early training under Max Planck at Munich, and is well known for her researches in theoretical and applied physics carried on in collaboration with many of the leading scientific figures of our time. She is currently on the staff of the University of Antigonish.

D. F. S.

# the pegaso

*The Simplest Complex Automobile on the Road*

By Karl E. Ludvigsen, '56

In October of 1951 the first notices were published of a marvellous new automobile, which, it was anticipated, would soon move into the hallowed ranks peopled by Ferrari, Jaguar, Alfa-Romeo, Lancia, et al. Now, two years later, many are inclined to relegate it to the ghostly group including Tucker, Davis, and the Cisitalia, Sacha Gordine, C.T.A.-Arsenal, and B.R.M. racing cars. The Pegaso was a car of great promise, fathered by a great designer and given birth by a well-known motor truck manufacturing concern. However, we may well ask, "Were their intentions honorable?" Let us first examine the parents, as a preliminary to an investigation of their progeny.

Wilfredo P. Ricart, now in his early fifties, is responsible for the concept of the Pegaso as a spare-no-expense sports edition of current racing practise. He has been concerned for 30 years with sports and racing cars in general, and was for ten years head designer of Alfa-Romeo's racing department. During this time he developed the fabled blown 1½ liter flat 12 cylinder Alfa racing engine, which was tried during and after the war, but never raced. He was in Italy at the outbreak of the Spanish Civil War, and remained there until its cessation. Thus Ricart was strongly influenced by Italian practise when he set out to design the first Spanish automobile since the Hispano-Suiza. He is President of the Spanish Society of Automotive Engineers, and was nominated Governor of the International Automotive Institute of Spain.

The distinctive "el Dominicano" at the Bridgehampton Schoolhouse Tour.

The Pegaso is built in the old Hispano-Suiza factory in Barcelona, under the auspices of the Empresa Nacional de Autocamiones, S.A. E.N. A.S.A., as it is known, is a Nationalized industry, well-known for its heavy-duty trucks and buses. The catalogue proclaims that some fifteen and a half million dollars are behind this venture, as a reassurance to hesitant prospects. Most of the parts for the Pegaso are made in Spain, while the center-lock wire wheels, Weber carburetors, Lockheed brakes, Bosch electrical system and, as I discovered, the Marshall-Nordec supercharger, are obtained from outside suppliers.

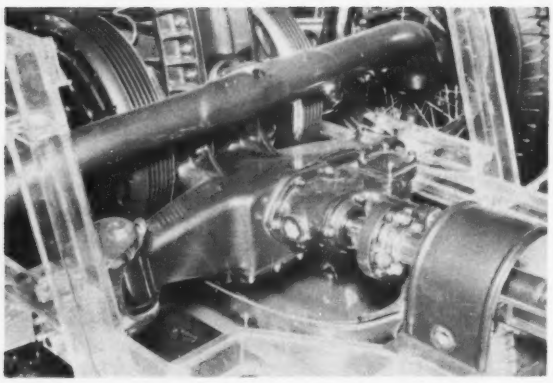
Ricart's design for the Pegaso is complex in general concept, but simple in detail. His object was to produce a sports car embodying the best elements of design current in Grand Prix racing cars at the time of conception. Some of these elements are the twin-overhead camshaft V-eight engine; the combined transmission and final-drive unit; the De Dion rear suspension, and the use of torsion bar springing all around. While these refinements often lead to complexity, in the Pegaso they are executed in a very straightforward manner. Indeed, Ricart seems at his best when working in accordance with these ideas, since the weak spots of the car's design are to be found where he has deviated from current practise and from simplicity. The Pegaso was intended to be "the right combination of the world's best designs." Let us examine the car and try to find where it falls short of this goal.

Light alloys are used extensively throughout the car, and particularly in the engine. A single light aluminum alloy casting comprises the block and crankcase, with the banks slightly offset to allow side-by-side connecting rods. The removable wet cylinder liners are forged steel, nitrided, and the bore is lapped and honed. Each liner has two rubber seals at its base. The crankshaft, with its four throws at 90 degree intervals, is of a special nitrided steel alloy, and is carried in five aluminum bearing shells, with forged aluminum

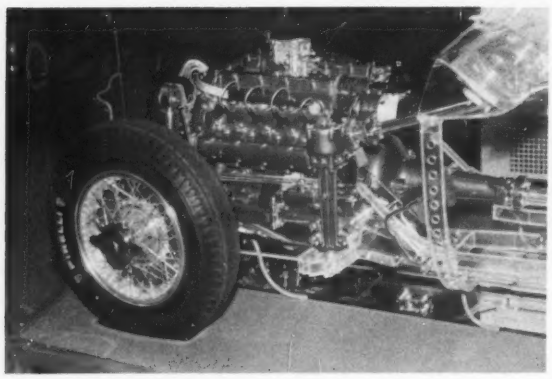
caps. The crank is dynamically balanced, and has a torsional damper at the front end, where power is also taken for the various pumps and engine accessories. The connecting rods are forged nickel steel, machined all over, with two bolts retaining the special aluminum alloy big end bushing which is free to rotate on both its inner and outer surfaces. A bronze bushing is used at the wrist pin end. The pistons for standard compression ratios are cast aluminum alloy, while those for extremely high racing ratios are forged aluminum. There is a single large stiffening rib under the crown, which is well contoured "to hold the charge up where the spark can see it." There are two compression and three oil rings per piston. The cylinder heads are of light alloy with stellite valve seat inserts and bronze valve guides. Each of the two camshafts per head is carried in five needle bearings, and the valves are operated through lightweight chill-cast piston-type tappets, which also operate in bronze guides. The tappets are helically slotted for reduced weight and improved lubrication. As in the Jaguar XK120 engine, valve clearance is adjusted by means of removable steel shims between the valve stem and the inner surface of the tappet, against which the two concentric valve springs also operate. The intake valve, opening into a hemispherical combustion chamber, is of bronze-aluminum and has a hollow tulip-type head. The high-speed tool steel exhaust valve has a flat face and a deflector to protect the valve guide, and the stem is sodium filled and electrically welded. The original plan was to offer a system of three roller chains to drive the camshafts on touring models and a gear drive for racing versions, but the latter system seems to have been standardized for most models. The water pump, fan, and two oil pumps are driven from the camshaft gear train and are housed in the front of the gear cover. The water from the high speed centrifugal pump is carefully ducted to the exhaust valves and the wet liners, and a special duct leads to the intake manifold to warm the mixture. A thermostatically controlled shutter aids rapid warming up. Lubrication is by the dry sump system, with a scavenger pump retrieving oil from the ribbed light alloy pan and delivering it to the combined oil cooler-reservoir located below and in unit with the radiator. A pressure pump then passes the oil through two disc-type filters mounted in parallel, which clean themselves automatically when the clutch pedal is depressed. A pressure differential valve admits oil at lower pressure to the valve mechanism. There are several carburetor options, the standard instrument being a single Weber type 36 D.C.F. 1 dual choke instrument. With its duplicated jet adjustments, this is the equivalent of two carburetors. Also available is a manifold accommodating four Weber type 36 D.C.F. 3 units, which provide a separate venturi for each cylinder. A third possibility is the use of a Roots-type supercharger made by Marshall-Nordec of England. This blower has hollow two-lobe rotors, an aluminum case, spur gearing on the driven end, and Hoffman ball bearings. It is driven at engine speed by a short shaft, splined at the blower end and geared to the right bank camshaft drive. It draws the mixture from one Weber horizontal twin-choke instrument. Two pumps are used to supply fuel from the twin tanks, which are so formed to accommodate the rear mounted gearbox. A mechanical pump is driven from the rear of the right hand intake camshaft, and a pressure release valve and return pipe see that any excess fuel is returned to the tank. An electric Autopulse pump mounted in series is supplied for use in town. An air duct and cleaner are mounted under the hood, and an outlet mates with the carburetor top when the hood is closed. Again, the original plan was to offer a Bosch coil ignition system with dual distributors and mechanical advance as standard equipment, and a magneto optional, but the latter, a Bosch type MZEZ 20/1B3, is the only one mentioned in the owner's manual. The coil system was to use Bosch 225 or 240 plugs, while 260 to 310 plugs are fitted with the magneto. The only V-belt in the car drives the rear center-mounted 12 volt generator from the back end of the left intake camshaft. The exterior of the engine speaks its fine design, all parts being either polished or brown crackle finished.

The dry single-plate clutch operates inside an aluminum-alloy housing with an extension which shortens the open driveshaft. The latter is of tubular steel and has a Layrub flexible coupling at each end. All speeds in the gearbox are indirect, as the drive passes beneath the differential to the primary gears, the secondary shaft being above and running forward to the final drive gear. Thus,

The very neat coupe by Touring seen at Bridgehampton.



The rubber disc for lateral axle location is shown clearly here.



The Pegaso has a very high finish of all engine and chassis parts.

all gears are helical, some having pierced webs to reduce weight. Speeds are engaged by dog clutches, the whole system being reminiscent of motorcycle practice. The case of the rear assembly is of aluminum, and is cast in three pieces. The main unit carries the Gleason spiral bevel final drive, the ZF cam-type limited-slip differential, and the transmission gears. An extension bolted to the rear of the case carries the first and reverse gears, while a rear cover contains the transmission oil pump and filter. The transmission is fully pressure lubricated, with a pump drawing oil from the wet sump and passing it by a relief valve and through a filter to the drilled shafts. A dipstick to check the oil level is accessible through

Not bad looking, the panel that is.

## *Specifications*

ENGINE DIMENSIONS:

| | | | |
|---|---|---|---|
| Cylinders: | | | 90° V-8 |
| Bore 102B/2.5: | | | 75mm (2.95 in.) |
| 102B/2.8: | | | 80mm (3.14 in.) |
| Stroke: | | | 70mm (2.76 in.) |
| Cubic capacity | | | |
| 102B/2.5: | | | 2,472cc (150.5 cu. in.) |
| 102B/2.8: | | | 2,816cc (171.5 cu. in.) |
| Piston area: | | | |
| 102B/2.5: | | | 54.7 sq. in. |
| 102B/2.8: | | | 61.9 sq. in. |
| Valve angle from cyl. C. L. | | | |
| Intake: | 45° | | |
| Exhaust: | 49° | | |
| Valve head dia. | | | |
| Intake: | | 1.81 in. | |
| Exhaust: | | 1.49 in. | |
| Total valve area | | | |
| Intake: | | 20.6 sq. in. | |
| Exhaust: | | 13.9 sq. in. | |
| Valve lift: | | 0.33 in. | |
| Valve stem dia. | | | |
| Intake: | | 0.5 in. | |
| Exhaust: | | 0.56 in. | |
| Valve timing | | | |
| Inlet opens B.T.D.C.: | | | 25° |
| Inlet closes A.B.D.C.: | | | 70° |
| Exhaust opens B.B.D.C.: | | | 70° |
| Exhaust closes A.T.D.C.: | | | 25° |
| Valve clearance | | | |
| Intake: | | 0.020 in. | |
| Exhaust: | | 0.028 in. | |
| Tappet dia.: | | 1.77 in. | |
| Compression ratios | | | |
| 102B/2.5: | | | 7.90, 8.10, 8.50, 9.00 |
| 102B/2.8: | | | 7.80, 8.20, 8.80 |
| 102BS/2.5: | | | 6.50, 7.10, 7.50 |
| 102BS/2.8 | | | 6.00, 7.30 |
| Main bearing | | | |
| Diameter: | | 2.51 in. | |
| Width: | | 1.37 in. | |
| Connecting rod bearing | | | |
| Diameter: | | 1.37 in. | |
| Width: | | 0.75 in. | |
| Wrist pin dia.: | | 0.81 in. | |

ENGINE ACCESSORIES:

| | | | |
|---|---|---|---|
| Carburetor venturi dia.: | | | 40 mm |
| Magneto spark advance | | | |
| Initial: | 17° | | |
| Automatic: | 45° | | |
| Total: | 62° | | |
| Plug size: | 14 mm | | |
| Plug gap: | 0.016 in. | | |
| Oil weight: | S.A.E. 30 | | |
| Oil pressure | | | |
| Mains: | | 71 p.s.i. | |
| Valve gear: | | 14 p.s.i. | |
| Total oil capy.: | | 12.67 quarts | |
| Water capacity | | | |
| Motor: | | 9.50 quarts | |
| Radiator: | | 12.67 quarts | |
| Total: | | 22.17 quarts | |

Supercharger
- Boost: 9 lbs.
- Lobe length: 9.5 ins.
- Lobe dia.: 5.2 ins.

Gasoline capacity: 22 gallons
Min. gasoline quality: 80 octane
Electrical system: Bosch 12 volt
Generator: 150 or 300 watts
Battery: 60-82 amp./hours

ENGINE PERFORMANCE:

Torque:
- 102B/2.5: 137.5 ft. lbs. @ 3900 rpm
- 102B/2.8: 160 ft. lbs. @ 3600 rpm
- 102BS/2.8: 240 ft. lbs. @ 4000 rpm

Maximum effective revs.
- 102B/2.5: 6300 rpm
- 102B/2.8: 6300 rpm
- 102BS/2.5: 6800 rpm

Maximum power
- 102BS/2.8: 250 bhp @ 6600 rpm

Dry weight
- Engine without clutch: 398 lbs.
- Clutch alone: 35 lbs.

TRANSMISSION:

Clutch dia.: 10 ins.

Gear ratios:
- top (o.d.) 0.86 to 1
- 4th 1.00 to 1
- 3rd 1.24 to 1
- 2nd 1.80 to 1
- 1st 3.00 to 1
- reverse 2.70 to 1

Final drive ratios:
- 12/45 or 3.75 to 1
- 11/46 or 4.18 to 1
- 11/48 or 4.36 to 1
- 11/52 or 4.73 to 1
- 10/52 or 5.20 to 1

Oil capacity: 7.40 quarts

Tire sizes: 5.50 x 16, 6.00 x 16, 6.50 x 16
17 inch rims available

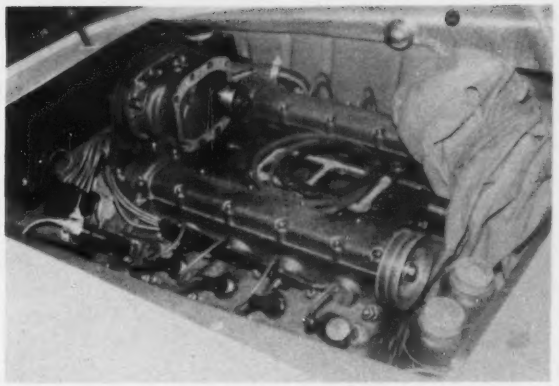
CHASSIS DETAILS:

Brake drum dia.: 12.8 ins.
Friction lining area: 190 sq. ins.
Steering wheel angle: 18°
Number of turns, lock to lock:
- Original: 4.0
- Current: 1.6

Turning circle dia.: 31 ft.
King pin length: 5 ins.

DIMENSIONS:

Wheelbase: 92 ins.
Front track: 52 ins.
Rear track: 50.8 ins.
Overall width: 62 ins.
Overall length: 162 ins.
Ground clearance: 6.3 ins.
Overall height: 51 ins.
Dry weights:
- Factory berlinette
  - Sports: 2430 lbs.
  - Touring: 2820 lbs.
- Open sports
  - Unblown: 2183 lbs.
  - Blown: 2337 lbs.
- Chassis only: 1950 lbs.

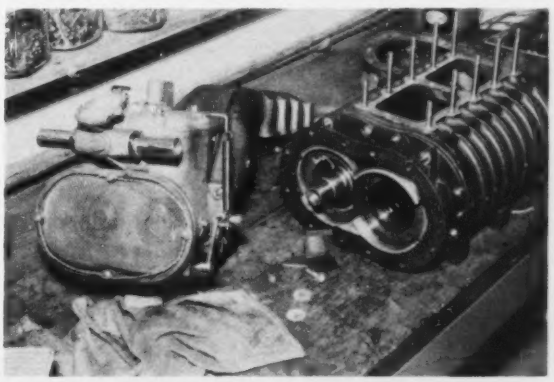


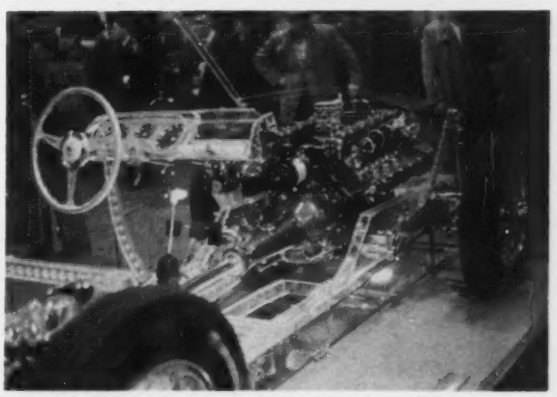
A view with the supercharger removed shows the internally splined driving shaft.

the trunk compartment. Gear selection is effected by a remote control unit operating through a single universally-jointed shaft. The rear brake drums are mounted on either side of the gearbox unit, as sprung weight. They are of Al-Fin construction, and have fins and vanes to draw air from the sides for cooling and to exhaust it at the rear. The chrome-nickel steel half-shafts have plain Hooke-type universal joints at each end, necessitating a splined slip joint on each shaft.

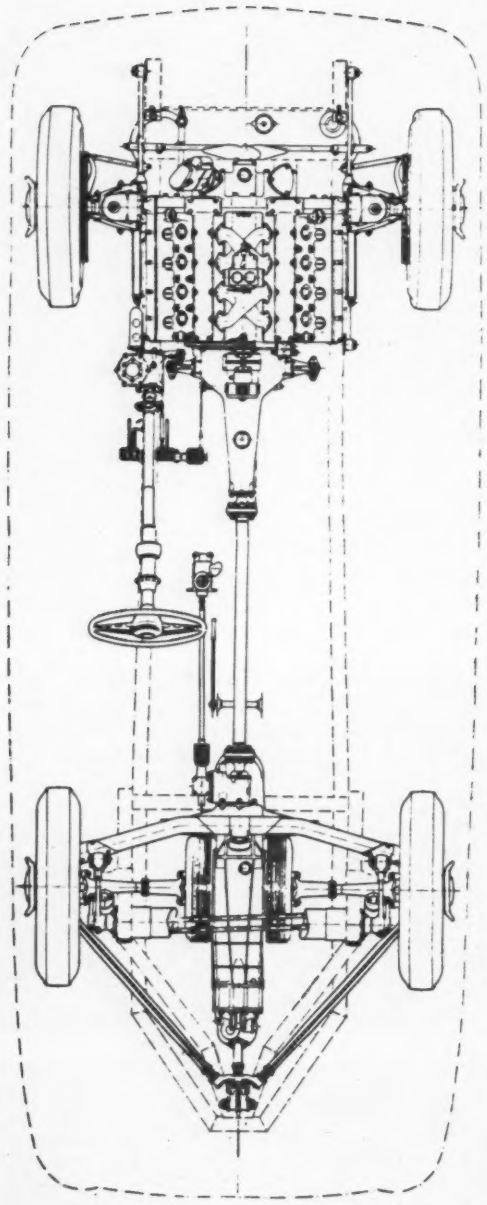
Rear suspension is by the De Dion system, the chrome-molybdenum steel dead axle tube crossing forward of the gearbox unit. A steel-sided vertical

The very large Weber carburetor has its own cast pipe to the blower.





The plastic members used in this display bear no relation to the actual chassis structure.



The main chassis units are distributed to give a high polar movement of inertia.

channel in the front of the differential housing receives a rubber-edged disc some 3½ inches in diameter which is mounted on the cross tube through a ball bearing. This system gives perfect lateral control and free vertical movement, and was employed by Mercedes-Benz and Allard. The placement of the torque reaction arms seems original, however. The arms go back from the hubs instead of forward, and have a common anchor at the center of the chassis instead of at the sides. This latter feature eliminates the need for a flexible joint in the De Dion tube to relieve torsional stress as was used by Mercedes-Benz and Auto-Union. At the chassis end of the pierced steel reaction arms there are screw adjustments to set the precise angle of the dead axle, and rubber bushings are used at the anchor as well as at most other linkage joints in the suspension. A six-inch link at each side connects the tube to the 31-inch torsion bars mounted side-by-side transversely above the drive unit. The telescopic double-action shock absorbers are mounted below the torsion bar levers so that they are extended on bump and compressed on rebound. These are of special E.N.A.S.A. design and manufacture, and, unlike common hydraulic units, they cannot be extended or compressed even slowly by hand.

The front suspension is the familiar parallelogram arm system, with some interesting variations. Each side of each individual A-arm is a separate forging, completely machined and assembled with bolts. The upper arm is 6½ inches long, while the lower is 7 inches. The inner ends of the arms pivot from a steel pressing, which in turn is attached to the frame by a single 2½ inch stud and nut. The unit is prevented from rotating under braking by an arm extending to the rear, which has a screw fitting at the chassis end for caster adjustment. A single longitudinal torsion bar is used on each side, splined at the middle to the lower arm and anchored to the chassis at each end, giving the illusion of two bars on each side. The original layout had the bottom end of the tubular shock absorber connected to the lower arm, but it has since been raised to the upper arm, where it is compressed on bump, in the usual manner. The arms and their pivots were also strengthened when this change was made. The brake drums are like those at the back, finned and pierced, but the backing plate is fitted with a scoop and there are two leading shoes in the Lockheed system. The master cylinder is of displacement type, as used in some Girling brakes, instead of piston type. There are two fluid reservoirs mounted on the firewall, and separate hydraulic circuits for front and rear brakes.

Steering is by worm and sector, the sector being at the top of a vertical shaft housing, from the bottom of which the longitudinal drag link is operated. A complex system of bell cranks and a tie rod transfer motion to the final steering rods, which are forward of and slightly below the lower suspension arm and one inch longer than that member. The steering box is of E.N.A.S.A. manufacture, and uses ball bearings throughout.

The Pegaso has no frame as such, but uses a combined chassis-body platform construction of electrically welded chrome-molybdenum steel. Stressed sheets and square-section members are used extensively, as are lightening holes. The

much-favored tubular structures are conspicuously absent. The engine is mounted on four rubber supports, and the transmission assembly uses three rubber bushings. The chassis structure differs greatly in detail with various types of body-work, no two examples in this country being precisely alike.

This car is supplied either with coachwork by the leading European custom body makers or with a straightforward coupe body built at the factory. The instrument and cockpit layout is basically the same for all models, the main difference being in ease of ingress and egress, which is exceedingly difficult in some of the coachbuilt editions. Once inside, however, the driver sits well down in the car, vision being good but not exceptional. The 17-inch steering wheel is adjustable 3½ inches fore and aft, and has two spokes in the standard version and three in special bodies. Instrumentation includes an 8000 r.p.m. tachometer, ammeter, water temperature, oil pressure and temperature, gasoline level, clock, and a 200 kilometers per hour speedometer. The three pedals are similar in shape and placed close together on the same level, giving plenty of foot room with the rear mounted gearbox. The clutch pedal travel is very stiff and short, while that of the accelerator is longer than normal. The unusually-shaped gear shift knob is very agreeable to the hand, and the remote control is positive and sure. It was noted that with the car at rest, the steering wheel could be moved two inches at the rim without affecting the angle of the front wheels. This was more pronounced on cars that had done an appreciable mileage.

A discussion of the engine should begin with the basis of its design, the cylinder arrangement and bore and stroke. A V-8 was chosen to give high piston area together with short overall length to conform to the very short wheelbase. All engines use the same 70 mm stroke, with alternative bores of 75 and 80 mm. This gives stroke: bore ratios of 0.93:1 and 0.87:1, which are in line with Ferrari's 0.85:1 in the "Mexico" model but well above the 0.81:1 of Buick's new V-8. This stroke gives the following piston speeds: 2890 f.p.m. at 6300 r.p.m.; 3040 at 6500, and 3120 at 6800. The hallowed 2500 f.p.m. is reached at 5440 revs., which, in overdrive 5th. with a 4.36 to 1 rear end, corresponds to 128 m.p.h. The piston areas of 54.7 and 61.9 sq. ins. are not only high as absolute values, but also indicate a ratio of piston area to capacity exceeded only by Ferrari and Porsche. The large bore that produces this useful area also allows the use of large valves. The valve area of the Pegaso is roughly equivalent to that of many big American V-8s, and, together with the direct method of valve operation, it produces exceptionally good breathing at high engine speeds. The use of piston-type tappets for o.h.c. operation has become popular since the war, and since the success of the Jaguar XK120 engine. Racing engines before 1939 almost exclusively placed pivoted fingers between cam and valve to take side thrust, but this method would be too complex for Ricart's ideal of simplicity of detail. The valve timing is extreme, the only American cars with longer open periods being the Buick and

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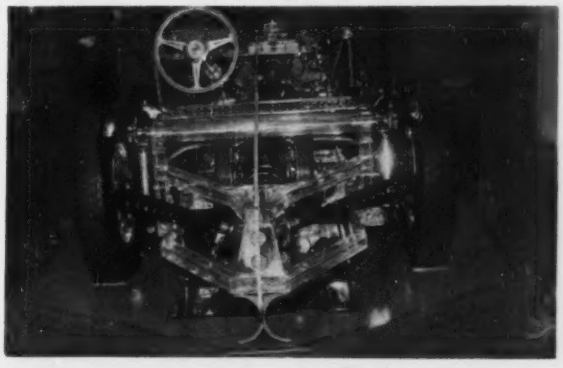
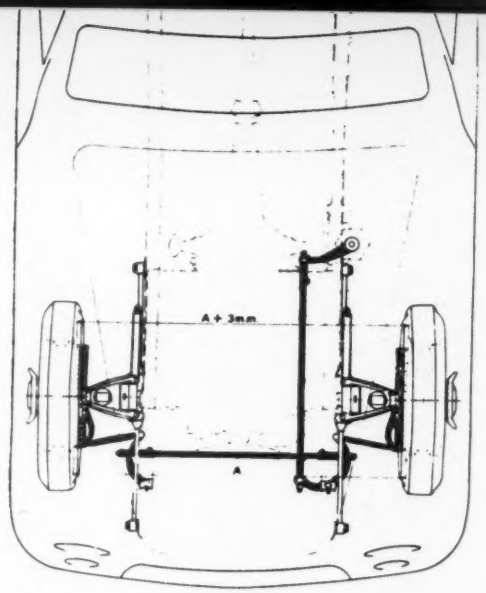


The deDion tube and radius arm mounting are unusual.

This is the single carburetor, gear-driven cam model.

Hudson, which have very "wild" cams. It also surpasses most "full-race" Ford grinds, and such standard sports cars as the M.G. and Jaguar. Internal cooling for valves, while popular in aircraft engines, was not employed on land until Mercedes, replete with aviation experience, introduced sodium cooling in the 1937 W125. The Pegaso exhaust valve, with its gas deflector and thick sodium-filled stem, also smacks strongly of aircraft practise. Camshaft drive by gears has been proven in racing but is an innovation in the sport-touring field. This is assuredly the most accurate and dependable method, but has heretofore been prohibitively expensive. The use of plain main and big end bearings is not unusual, but the use of a floating big end bushing and the very special aluminum alloy bearing composition are at this time unique to the Pegaso. The five rings per piston can be expected to give better oil control at the expense of mechanical efficiency. Combination of water radiator with the entire oil reservoir is unusual, but forward location of the tank in a dry sump system has been used before by Aston-Martin, among others. Thus it can be said that the engine design utilizes many principles proven in racing and general use, and ventures into the unknown only in details which do not affect the basic design. A defect in one of these details, then, can be easily remedied without drastic alterations to the engine as a whole. Given the satisfactory performance of these details, the engine should prove to be a reliable and versatile unit.

The drive system and gearbox location are among the most unusual features of the Pegaso, but we again find that the innovations have been executed in the simplest possible way. With a rear-mounted transmission the clutch could be either in unit with the engine or with the gearbox. The latter, used by Lancia, would seem to be preferable, since the speed of synchronization in the transmission depends on the speed difference and on the moment of inertia of the shafts and units being speeded up or slowed down. Placing the clutch together with the engine would add the whole length of the drive shaft to this burden. but Pegaso has joined most G.P. racing cars in adopting this solution, in recognition both of the ease with which a single-disc clutch can be mounted on the flywheel and of the difficulty with which it can be accommodated in a complex rear suspension. Locating the gearbox behind the rear axle in a front-engined design is distinctly unusual, but is simply a further development of pre-war Mercedes-Benz racing policy. The placement of the gearbox weight at the rear of the car not only improves weight distribution, but also follows the M.-B. fetish of disposing heavy masses as far away from the center of the car as possible, to increase the polar moment of inertia of the chassis as a whole. This increases the resistance of the car to any external slewing couples. The gear ratios are clearly chosen for high speed work, 4th being for maximum speed and overdrive for touring. Top speeds in gears at 6300 r.p.m. are 43 m.p.h. in first, 71 in second, 103 in third, 128 in fourth, and an impossible 148 m.p.h. in top. The Z.F. limited slip differential is in common use in racing cars and, due to its inherent inefficency, on a sharp corner it may absorb up to 50 per cent of the input power, greatly increasing control and




The Pegaso steering linkage is extremely complex.

traction. This power absorption increases with the decreasing radius of the turn. The half-shafts use the expedient of two Hooke-type universals and a splined section, in place of the complex De Dion pot-type joint used by Mercedes. The splined center-lock wire wheel hubs are considerably larger than standard, to give the wheel more lateral support and to distribute all stresses.

The front suspension and steering seem to be among the weaker points of the car. Conspicuous changes have been made in those units since the car's inception, all in the direction of increased stability and control. The change in shock absorber mounting has already been noted, and it is likely that the original position of the damper prevented adequate bracing of the upper arm, since the shock had to pass through that member. The method of attaching the suspension assembly to the frame is distinctly unusual, but with the torque arm extending backwards it should be sufficiently rigid, and it certainly makes removal of the unit a simple task. Since the bottom suspension arm is only slightly longer than the top, there will be small changes in both camber and track when the wheel is displaced, giving a front roll center just above ground level. This geometry has been used with success by many marques, but it is again possible that the earlier Pegaso units lacked the rigidity to cope with severe braking and cornering stresses. The excessively stiff shock absorbers may be a stop gap remedy in lieu of more exact knowledge, as was the hard springing on the first independently suspended racing cars. To quote *Autocourse*, on the subject of the Monaco sports car race in June of 1952, when the Pegasos were still using the earlier suspension: "Prominent among the entries were two Pegasos, but while one was given credit for a reasonably fast lap during the training period, it was clear that neither car was *au point*, and both gave considerable visual evidence that the steering and general stability were far from correct. Both were wisely withdrawn." Also *Auto* magazine, on the same subject: "Their biggest difficulty seems to lie in steering and brakes." Here accusing fingers are pointed at the steering, which seems to be needlessly complicated. There are no less than eight ball joints and two pivots, all of which require

greasing every 1500 kilometers and are potential sources of lost motion and friction. Nor is the worm and sector gear known for its freedom from these maladies. The actual presence of play in the system has been mentioned before, and it is difficult to see why the marvellously direct and precise rack and pinion gearbox was not used. Here Ricart has succumbed to the temptations of complexity, and the car is much the worse for it. The early cars had a steering ratio that required four turns of the wheel from lock to lock, and this rather high figure has since been reduced to 1.6, which, with the very small turning circle, should give rapid response to the wheel. It is difficult to get an authoritative report on the actual handling characteristics of the car, since most of the so-called "road tests" consist of wild rides down Long Island byways with Señor Palacio executing 180 degree spins to demonstrate the "stability" of the Pegaso. Perhaps it has some of the tricks of the Cunningham C4R coupe, which would change direction a full two seconds after the wheel had been turned. Or it may be like the Auto-Union, which would change direction without the wheel being touched. Whatever it may be, there exists a lack of balance at the front end of the car that prevents its full potentialities from being realized.

The racing record of the Pegaso, which will be consulted by every prospective purchaser, cannot be said to be encouraging. Their first appearance was at the aforementioned Monaco G.P., to which they brought two very standard-looking berlinettes, with four-carburetor engines. Jover and Palacio were the drivers in this pre-LeMans test, and they posted practise times of 55.3 and 54.8 m.p.h. respectively on this round-the-houses circuit. In comparison Stirling Moss in a C-type Jaguar and Levegh's Talbot circulated at 58.6 m.p.h. and the fastest Ferraris, Aston-Martins and Gordinis were all slightly above 58 m.p.h. Two Cadillac-Allards put up about the same practise times as the Pegasos, and finished last in the race. The fastest race lap went to Stagnoli on a 2.8 Ferrari, at 60.4 m.p.h. Thus they were wise to withdraw from this contest, and from the following LeMans classic. During the fall and winter they proceeded to develop special sports racing versions of the car, and to use superchargers more. Palacio achieved some success in Spanish hillclimbs with a roadster that strongly resembled the much discussed "El Dominicano" coupe with the top removed. Just before the 1953 LeMans contest a perfectly fantastic Pegaso was seen on test at Monthlery. The engine was conventionally placed, but the driver was seated directly ahead of the right rear wheel, his head and shoulders enclosed in an airplane-style canopy that faired back to a fin at the rear. The "passenger's seat" was a hole in the corresponding position on the left hand side of the car. Thus the passengers were actually occupying the fenders, while the hood simply swept back over the engine in a smooth curve to the tail of the car. The engine was two-stage blown, and there was an air-brake located *underneath* the car. Such a car would have an absolute minimum of frontal area and excellent aerodynamics. It seemed to conform to the F.I.A. rules defining a sports car, and was destined to appear at LeMans, but it was destroyed by an unfortunate fire at the factory. Thus the cars appearing for practise at the Sarthe circuit were the open roadsters described above. Spectators early in the prerace week were treated to the sight of a Pegaso manned by Jover hurtling full bore past the pits and into the following bend, crashing about the track before coming to rest on the inside of the turn. The other Pegaso was quickly scratched. Shortly after LeMans the Cunningham team manager, Stanley Sedgwick, visited the E.N.A.S.A. works and found the Jover car being disassembled, as well as some twenty cars and chassis in process of assembly in the small shops. Thus there is some small production, with most bodywork by specialist coachbuilders. The LeMans prototype shows the direction in which Ricart and his crew are headed, and it is certain that few uninteresting cars will emerge from the Spanish works.

An examination of the Pegaso has revealed a car whose engine has great potentialities, which are restrained by an underdeveloped chassis. It seems highly likely that the faults of the chassis are attributable to the lack of far-reaching laboratory and track tests of the components involved. The question of whether or not the Pegaso works *wants* to test these components is not the concern of this article. E.N.A.S.A. can continue to regard their production as a high-speed touring car and attempt to market it on its merits as a pretty piece of machinery, but such a car must always have claims to some competitive successes, past or present, particularly in the Pegaso's stratospheric price range. The racing driver will buy a Ferrari; the fast tourer, a Bentley Continental. The car must be proven in competition to be of any value to anyone. At present it is not even a good advertisement for Nationalist Spain.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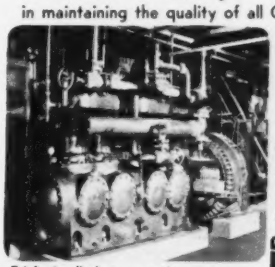

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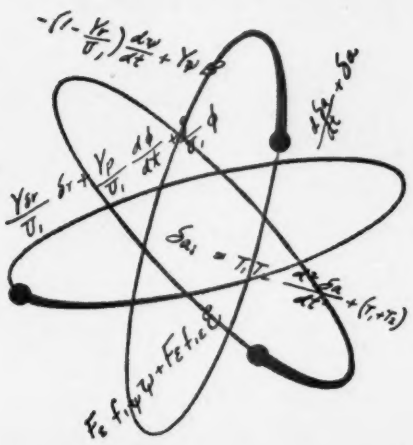

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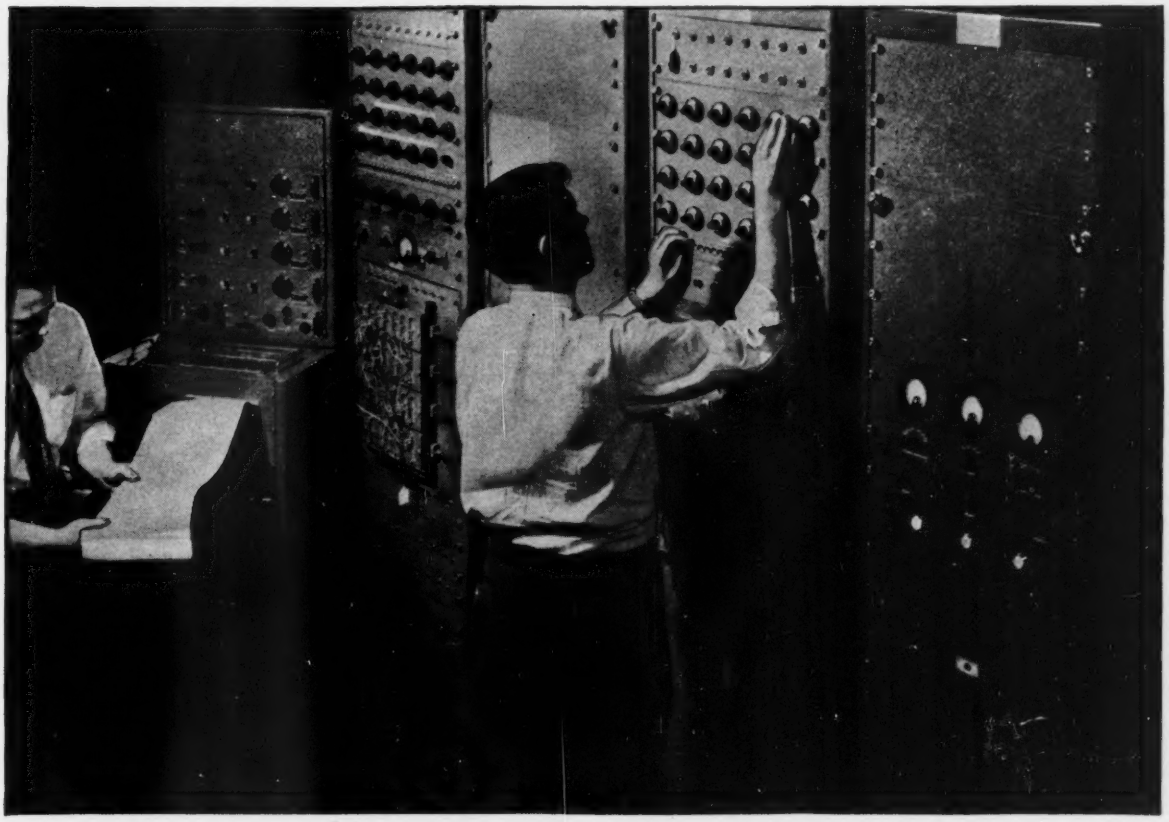

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# the lesagian theory of gravitation

By Dr. Hermatilda Klutz

*Professor at the University of Antigonish*

Ever since Newton presented his principle of gravitational action at a distance, physicists have regarded it as a concrete empirical explanation of the mechanical relationship between distant bodies. However, many have felt that the nature of the attraction is a mysterious *why*, since it was considered most unnatural for one body to affect the motion of another body without being in contact with it, even indirectly. Ninety-six years after Newton published his principle, LeSage of Geneva published his explanation in the Memoirs of the Berlin Academy.

The ingenious LeSagian Theory of Gravitation gave the *why* of the principle that every particle of matter attracts every other particle of matter with a force which is directly proportional to the product of their masses, inversely proportional to the square of the distance between them, and directed along the straight line joining the two particles. LeSage hypothesized the existence of corpuscles of *ultramundane* which are perfectly hard and inelastic, and which travel through space in random directions at very high speeds. The concentration of the *ultramundane* in space is quite high while the size of each corpuscle is very small. Whenever a body exists in space, it acts as a partial obstruction to the *ultramundane* by blocking the path of a small percentage of the corpuscles and acquiring their momenta. When a body is alone in space, the rate of change of momentum caused by the collisions between the body and corpuscles travelling in all directions (as molecules in a gas) is zero. When, however, two bodies exist in space, they act as reciprocal shields to the *ultramundane*. In figure 1, two bodies are situated in streams of *ultramundane* whose components are from left to right or from right to left. Streams with components not in these directions are not considered since there is no reciprocal shielding. It is evident that the transfer of momentum from the absorbed corpuscles to the bodies results in a force which tends to bring the two bodies together. The mutual attraction is thus presented, not as a pull, but as a push.

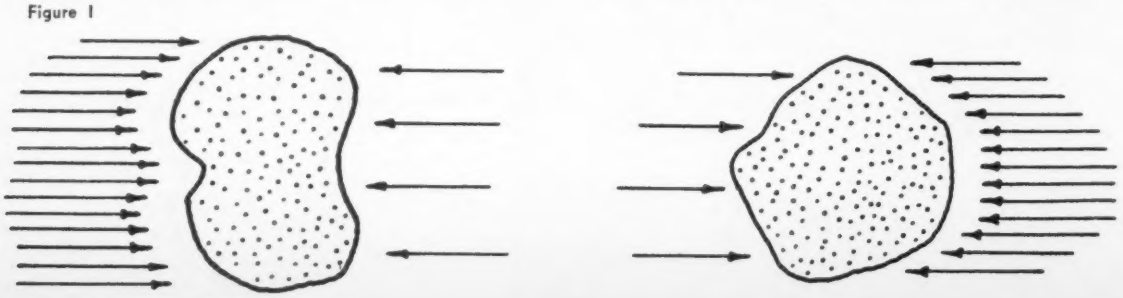
LeSage further hypthesized that the rate of collision between the *ultramundane* and a body in space is proportional to its thickness and density. From this he concluded that the attraction between that two bodies is directly proportional to the product of their masses. That the attraction is inversely proportional to the square of the distance between them also follows from the original hypothesis. This can easily be shown for two bodies when the distance between them is large compared with their sizes. Consider only the attraction between one body and a particle of the other. As the distance between the particle and the body is doubled, the solid angle subtended by the body with a vertex at the particle is quartered. There is, therefore, only one quarter as much interaction between the *ultramundane* and the body and the particle, and the force between them is quartered. See figure 2. As any distance is changed by a factor m, the solid angle, and consequently the attraction, is changed by a factor $1/m^2$.

In figure 3, three spheres are situated with their centers of gravity along the same straight line. Since the existence of a third body does not show any empirical change in the magnitude of the force of attraction between any of the two bodies, the percentage of the *ultramundane* colliding with the matter of the bodies must be very low. LeSage concluded that matter is a sort of a cage work, that is, mostly space, and that most of the corpuscles of the *ultramundane* pass through the empty space of the cage work. Indeed, modern physics has shown that most of the space in an atom is empty of matter. A further conclusion is that the corpuscles are many in numbers yet extremely small in size.

It is known that the inverse square law of action at a distance applies between such distant bodies as the sun and its outermost planets. The *ultramundane* travelling in one direction between these distant bodies must therefore not have many collisions with the *ultramundane* travelling in the opposite direction, and the mean free path of a corpuscle must consequently be astronomically large if not infinite.

Consider a body alone in space and gaining no momentum from the *ultramundane*. Now imagine that it is set in motion at a velocity v relative to its original velocity. If the velocity of the *ultramundane* is V, the ratio of corpuscles striking the forward side of the moving body to those striking the backward side of the body is $\frac{V+v}{V-v}$. Hence, unless V is very large compared with v, the body will show an appreciable negative acceleration and gradually revert to its original velocity. This would be in violation of Newton's First Law of

Figure 1



Motion. Therefore, LeSage concluded, the *ultramundane* travels at a very high speed. In the light of modern physics and with the aid of the Special Theory of Relativity, we can see that it is impossible to establish an ether of zero velocity toward which bodies of other velocities tend, but if we hypothesize that the *ultramundane* travels at the speed of light, no matter what the velocity of a body be relative to its original velocity, both sides of the body receive the same amount of impacts from the *ultramundane*. The corpuscles always maintain the same velocity relative to the body; that is, they travel at the speed of light. Consequently, there is no change in the momentum of the body, and Newton's First Law of Motion is not violated.

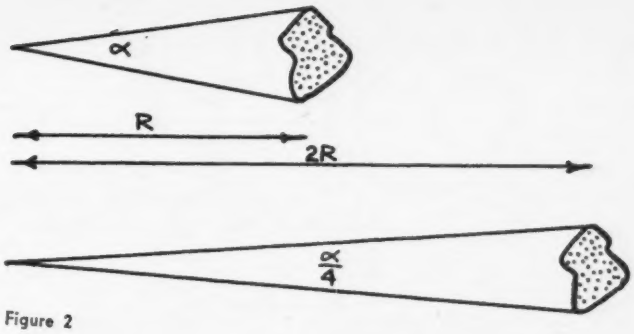


Figure 2

The LeSagian Theory of Gravitation accounts remarkably well for Newton's principle of action at a distance, yet there are numerous flaws in the theory which later physicists have tried to eliminate by modifying or revising the theory. For example, the theory violates the Law of Conservation of Energy which, when LeSage published his theory, was unknown. If the corpuscles of the *ultramundane* are inelastic as LeSage hypothesized, every body in space absorbs energy at a measurable rate. As a matter of fact, the rate would be so high that the earth would absorb enough energy to make it luminous. If, however, bodies in space do not absorb any energy from the *ultramundane*, the collisions between its corpuscles and matter are completely elastic and every colliding corpuscle would bounce back in the direction from which it came with its original velocity. In that case, however, the reflected *ultramundane* would interact with the matter of a body in such a manner as to cancel out the regular force of attraction. In figure 4, consider the simple case of two spheres of the same size. Suppose that one million corpuscles reach each of the spheres from outer space every second, and that every second, two corpuscles have perfectly elastic collisions with each sphere. In one second, one million corpuscles travelling from right to left enter Sphere II and one million minus two leave Sphere II continuing in the same direction toward Sphere I. In the same second, one million corpuscles travelling from left to right enter Sphere I, and one million minus two leave Sphere I in the direction of Sphere II. Suppose that, in Sphere I, the two colliding corpuscles bounce at points A and B. Then to the left of plane *a*, one million corpuscles are travelling in both directions, while between planes *a* and *b*, one million minus one corpuscles are travelling in both directions, and to the right of plane *b*, one million minus two corpuscles are travelling in both directions. There is, therefore, no change in the momentum of Sphere I, and, analagously, of Sphere II. Collisions between corpuscles traveling from right to left with Sphere I and between corpuscles traveling from left to right with Sphere II are neglected for simplicity. Hypothesizing that the particles are elastic, therefore, leads only to another impossible situation.

The only alternative left is to assume that the bouncing corpuscles do not transmit their energies, but, rather, retain them in the form of spin and vibration. The kinetic energy of the *ultramundane* would become energy of spin and vibration, and eventually either an equilibrium between

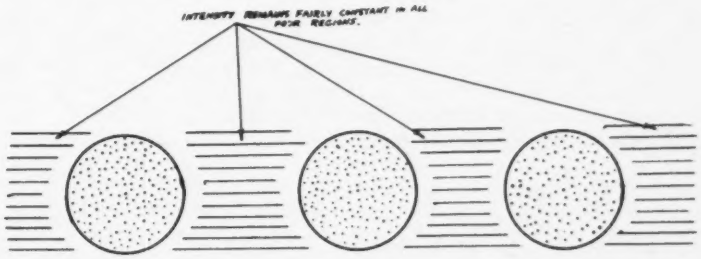
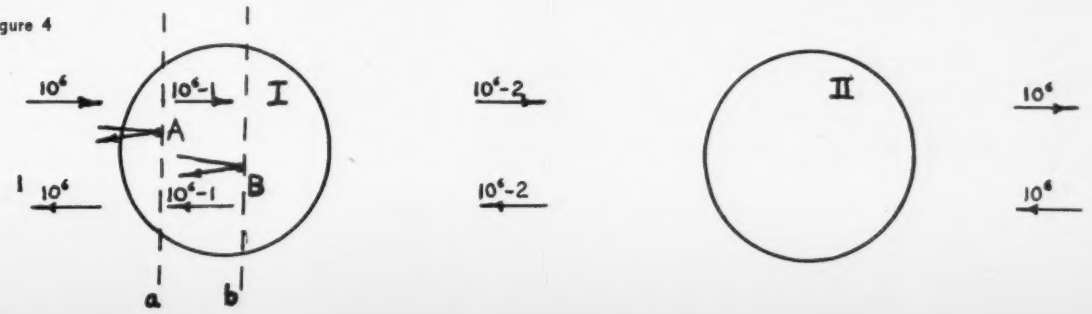


Figure 3

the three forms of energy would be attained or the kinetic energy density of the *ultramundane* would continually decrease. As a consequence of the second alternative, the universal constant of gravitation would no longer remain a constant, but it would vary as a function of time, and the law of gravity would gradually be repealed.

To LeSage's assumption that the rate of collision between the *ultramundane* and a body in space is proportional to the thickness and density of the body, must be added that it is also propor-

Figure 4



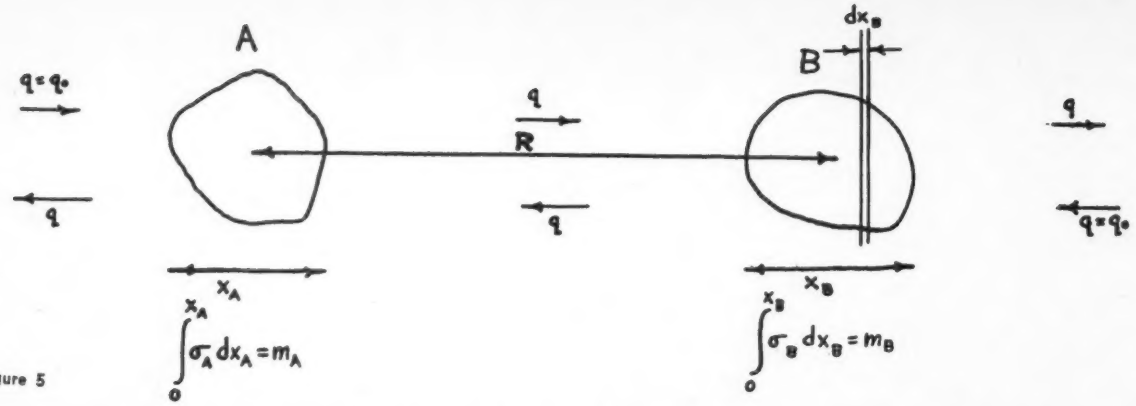



Figure 5

tional to the intensity of the *ultramundane* which is not necessarily constant. Inside of any body of matter, the intensity will be lower by a small amount than the intensity out in space far from any matter. Let q be the intensity at any point in space, $q_o$ the intensity at a point in space far from any body of matter, $\sigma$ the density per thickness of unit area, x the thickness of a body, and k, a constant. Then:

$$dq = -k_1 q \sigma dx$$

$$q = q_o e^{-k_1 \sigma dx}$$

According to the LeSagian Theory, the force F between Bodies A and B in figure 5 is:

$$F = \frac{G\sigma_A\sigma_B x_A x_B}{R^2} = \frac{Gm_A m_B}{R^2}$$

where G, the constant, turns out to be the universal constant of gravitation. If, however, the change in the intensity of the *ultramundane* is taken into account, we find the force by treating each body in turn. Let $\varphi$ be a function of the density, thickness and intensity of *ultramundane* of Body A, and $k_2$ another constant. Then:

$$dF = \frac{\varphi k_2 q \sigma_B dx_B}{R^2}$$

$$F = \frac{\varphi k_2 q_o}{k_1 R^2}(1 - e^{-k_1\sigma_B x_B})$$

$$e^{-k_1\sigma_B x_B} = 1 - k_1\sigma_B x_B + \frac{1}{2}(k_1\sigma_B x_B)^2 - \frac{1}{6}(k_1\sigma_B x_B)^3 + \cdots$$

$$F = \frac{\varphi k_2 q_o}{k_1 R^2}\left[(k_1\sigma_B x_B) - \frac{1}{2}(k_1\sigma_B x_B)^2 + \cdots\right]$$

Then operating on body A and calculating in the same way, we find the force:

$$F = \frac{k_2^2 q_o^2}{k_1^2 R^2}\left[(k_1\sigma_A x_A) - \frac{1}{2}(k_1\sigma_A x_A)^2 + \cdots\right] \times \left[(k_1\sigma_B x_B) - \frac{1}{2}(k_1\sigma_B x_B)^2 + \cdots\right]$$

Cancelling out the $k_1$'s and ignoring all terms containing $k_1$ in powers of one or higher because $k_2$ is very small on the basis of the relationship:

$$k_1 = -\frac{1}{q\sigma}\frac{dq}{dx}$$

where $\frac{dq}{dx}$ is very small by hypothesis, we find that:

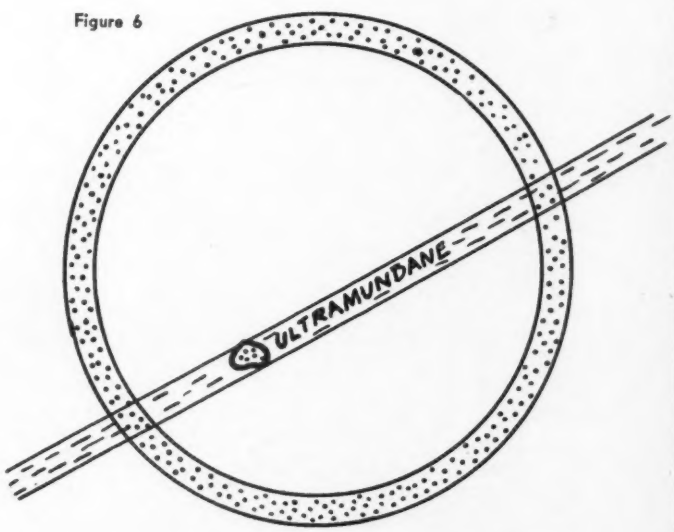
$$F \approx \frac{k_2^2 q_o^2 \sigma_A \sigma_B x_A x_B}{R^2} = \frac{Gm_A m_B}{R^2}$$

Thus, the revised theory presents a law of gravitation which is only an approximation to Newton's, but, at that, an extremely close one.

The conclusions that the corpuscles of *ultramundane* travel at the speed of light, possess extremely high penetrative properties, and have, perhaps, an infinite mean free path suggest, through analogy, the possibility that the *ultramundane* might actually consist of electromagnetic waves with wave lengths much shorter than those of cosmic rays. Gravity would thus be ex-

*(Continued on page 59)*

Figure 6



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**SILICONES AND THE FUTURE**—Even the scientists don't know all the answers about silicones. But they do know there is an exciting future ahead for them. The people of Union Carbide, who pioneered in many of the special silicones now used by industry, are helping to bring that future closer to all of us.

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# biogeochemistry

*Biology and Chemistry Combine with Geology to Find Ore*

By Herb Jacobson, '54

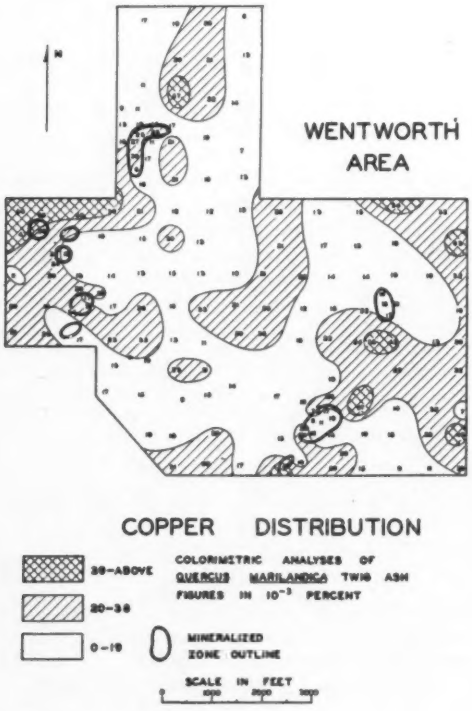
The pick and shovel prospector is rapidly being replaced by more scientific methods of finding economically valuable ore deposits. Geologists now have many tools at their disposal that help them find exploitable ore deposits. Geophysical methods such as measurement of distortions in the earth's magnetic and gravitational fields have occasionally been used in searching for ore deposits. These methods, however, give little indication of what kind of ore is buried below the surface and their usefulness is therefore limited.

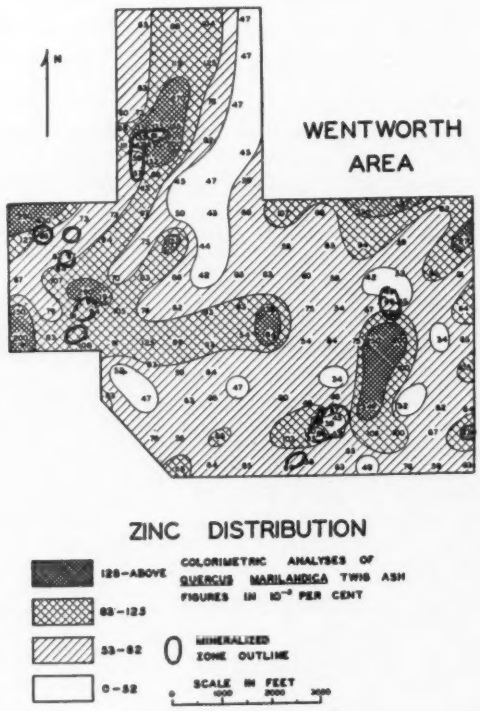
An innovation of the last few years enables the geologist to find buried ore bodies and to know which elements are most abundant. This is the new science of biogeochemistry. As the name implies, the knowledge of three sciences are combined in such a way as to create a method that has already been proven successful in locating previously undiscovered concentrations of ore. The biogeochemical method is applied where the surface is covered by thick layers of soil, gravel or glacial debris, making it almost impossible to obtain any information about the rocks and minerals underneath by standard methods.

The new method is based on the fact that traces of some elements are frequently found near the earth's surface if there is an ore body buried at a shallow depth. These traces could have reached the surface at the time of the ore deposit's formation or later by means of circulating ground water. The minute amounts of elements thus reaching the surface are later absorbed by plants growing in that particular area.

A knowledge of biology is needed to determine how the elements are absorbed by the plant, which elements are absorbed most quickly, and what portions of the plant receive the greatest concentrations of these elements. The plants serve to partly concentrate the elements in the soil. The concentrations of the elements in the plants are measured by chemical analysis. This is done by first burning the leaves or other parts of the plant to an ash, and then determining its mineral content. When samples are taken of several plants over a wide area, soil zones can be found that are rich in certain elements indicating the possible

Figs. 2 and 3. The Wentworth Area is one where the elements in the subsurface ore bodies and the outlines of these bodies were well known. Biogeochemical maps of the area show effective correlation of trace elements found in the soil with the ore bodies below.



existence of an ore deposit underneath.

In its present form biogeochemical prospecting for ores has four distinct phases:

1. Collection of plant samples.
2. Chemical analysis of plant samples.
3. Placement of the obtained data on a map.
4. Geological interpretation of the map.

The collection of plant samples suitable for analysis and likely to give significant results involves many variable factors that must be considered. For instance, which part of the plant has a mineral content that best reflects that of the soil? (It has been found that young twigs from one to three years old contain a high concentration of elements present in the soil.) To eliminate variations in the mineral content of the plants caused by differences in drainage, pH of soil, and type of overburden, several different plants are used in sampling. Common trees such as hemlock, pine, spruce, cedar, maple and birch have been utilized. The choice of plants for sampling depends on what element is being sought, on the terrain, climate, plant abundance, etc. The spacing of the samples is, of course, different for each survey, but generally samples are taken at intervals of 100 to 300 feet. Obviously, sampling depends on many variable factors that can not be accurately measured thus limiting the accuracy of this phase of biogeochemical prospecting.

The rather large possible margin of error in the collection of samples is compensated by comparatively accurate methods of chemical analysis. Two fast and sufficiently precise methods are now in use to detect small amounts of certain elements present in the ash of the plant samples. The chemical tests, however, cannot be applied to the samples before the organic matter has been removed.

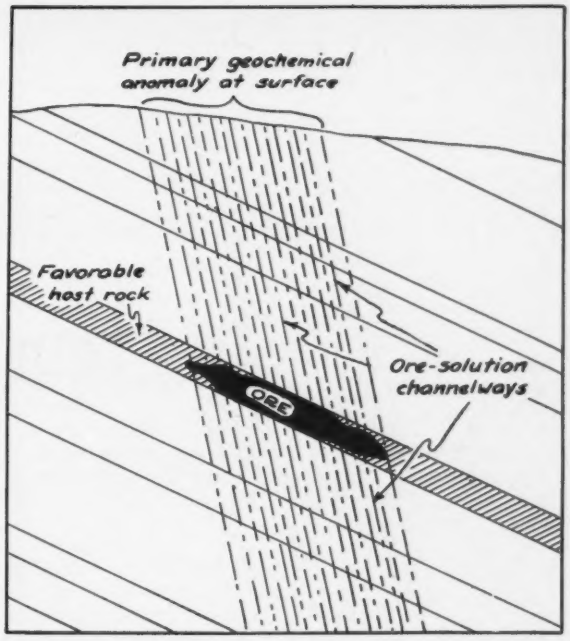
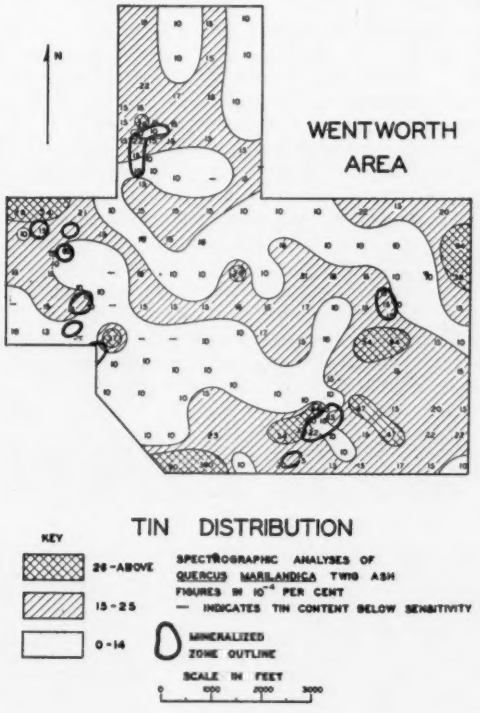
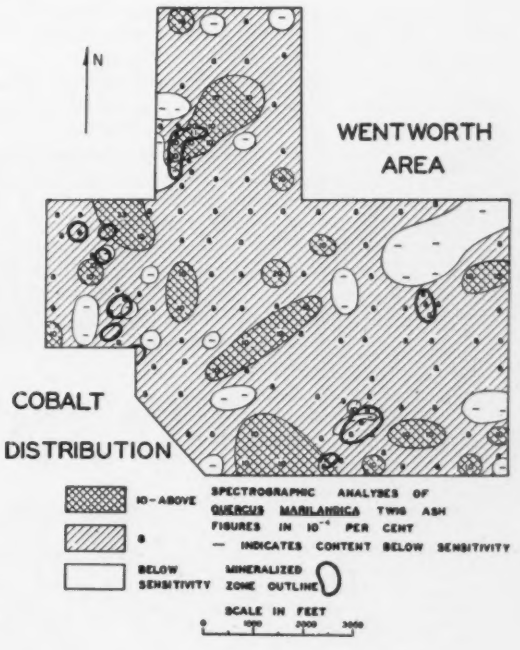


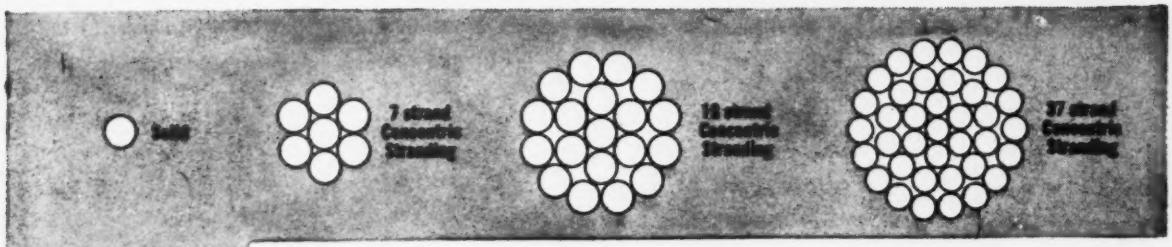

Fig. 1. This idealized diagram illustrates how a large concentration of an element on the surface can indicate the presence of an orebody below.

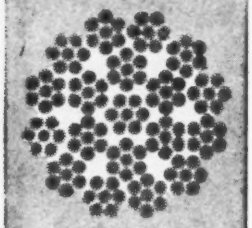
The simplest analytical method utilizes a kind of heavy metal indicator known as dithizone (diphenylthiocarbazone). This indicator can be used when testing for silver, copper, zinc, co-

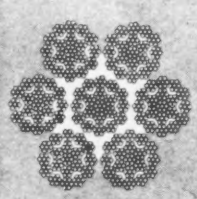
Figs. 4 and 5. These two maps of the Wentworth Area illustrate that tin and cobalt distributions on the surface do not always correspond to the ore bodies underneath. Therefore, in its present form biogeochemical prospecting cannot yet be used in searching for all metals.

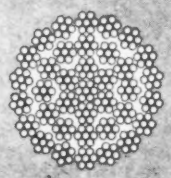


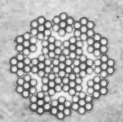



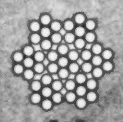



No. 2 in a series

# The Importance of Electrical Conductors

**In the ability to transmit electricity,** all forms of matter may be divided into two general classes, namely, conductors and insulators. Conductors permit electric current to flow readily; that is, they offer little resistance to its flow, whereas, insulators offer relatively great resistance to the flow of electricity. All substances at normal temperatures offer some resistance to the flow of electric current. In general, the metals are good conductors, while glass, oil and most organic substances are classed as insulators. Although silver offers the lowest resistance to the flow of electricity of the common metals, its cost is such that it is not widely used as a conductor. The conductors most generally used in the cable industry are made of copper or aluminum.

The manner in which electricity flows through elementary material may be readily visualized from the modern concepts of the structure of matter. According to these concepts all elements are made up of minute indivisible particles called atoms. These in turn are composed of a positively charged nucleus around which one or more very small negatively charged particles, called electrons, rotate at high velocity. In conductors, some of these electrons are free to move when only a small difference of potential is applied to the ends of the conductor and, since they are negatively charged, they flow to the positively charged end. This movement of electrons is electric current.

**In passing through conductors,** *the electrons must pass through the electron fields of many atoms. They thus collide with the atomic nuclei and other electrons. These collisions obstruct the flow of electrons and result in electrical resistance.*

The resistance of a homogeneous conductor of uniform cross-sectional area varies directly as its length and inversely as its cross-section, the length being in the direction of current flow. That is, $R = \rho L/A$ where, R is the resistance in ohms, L is the length in the direction of current flow, A is the area perpendicular to the length and $\rho$ is a constant of the particular material known as its specific resistivity. When the length and area are expressed in the same units such as L = one inch and A = one square inch, $R = \rho \times 1/1$ or $R = \rho$, the specific resistance of the material in ohms per inch cube.

The length and area of a conductor are generally expressed in other units than inches. The most commonly used unit of cross-sectional area used in the cable industry is the circular mil, usually designated as cir. mil or CM. This

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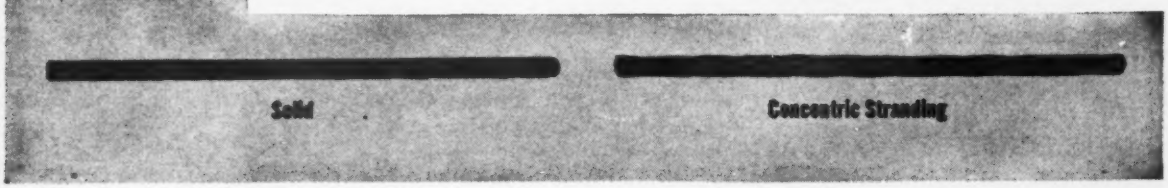

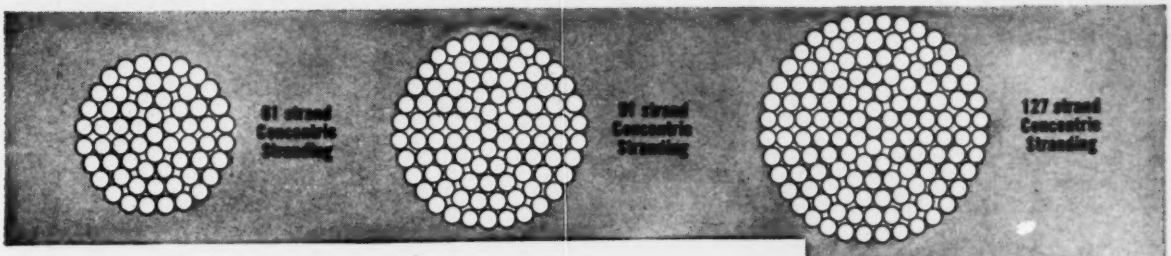


is the area of a circle whose diameter is one mil, 0.001 inch. The area of a circular mil is $\pi/4$ or 0.7854 of a square mil. The unit of length usually associated with this unit is the foot and the resistance becomes ohms per CM-foot. The resistance of annealed copper and aluminum per circular mil-foot at 20C are 10.371 and 17.011 ohms respectively. The resistance of a copper conductor 64 mils in diameter and one foot long thus becomes $10.371 \div 64^2$ or 0.00253 ohms.

**The sizes of electrical conductors** *are expressed in the United States in terms of the American Wire Gauge. This was originally set up on the basis of a geometrical progression of 39 steps or sizes between a wire 460 mils in diameter (Size 4/0) and a wire 5 mils in diameter (Size 36). The ratio of the diameter of a wire to that of the next larger size in this series is 39* $\sqrt{460/5} = 1.12293$. *This ratio has since been used to extend the American Wire Gauge (AWG) to sizes smaller than 36 AWG (5 mils). The sizes of conductors larger than 4/0 are expressed in circular mil area. The size of a conductor made up of a number of wires is determined from the sum of the circular mil areas of the individual wires.*

When current flows through a conductor there is, according to Ohm's law, a voltage drop of $E = IR$, where E is in volts, I is in amperes and R is in ohms along the conductor and power equal to EI watts is converted to heat. Since $E = IR$, this power converted to heat becomes $I^2R$ watts. These two factors, voltage drop and conductor heating, are of prime importance in the design of conductors. Conductors must be sufficiently large in cross-sectional area, that is, must have sufficient low resistance that the voltage drop does not become excessive. In good design this voltage drop should not exceed 3 per cent for power circuits or 1 per cent for lighting circuits. The conductors should also be large enough that their temperature does not exceed that for which their insulation is designed. This is referred to as the current carrying capacity of conductors. The current carrying capacities of the various sizes of conductors, conductor insulations and installation conditions have been established. It should be noted that the temperature attained by a conductor depends not only on the amount of heat generated but also on the thermal resistance of its surroundings.

**In addition to providing satisfactory** voltage drop and current carrying capacity, conductors must be designed to provide adequate flexibility during installation and service. This is accomplished by building up the conductor from one or more adequately small wires depending on the flexibility required. For example, the conductor for heater cord or welding cable which is subject to repeated flexing in service is usually made up of copper strands having a diameter of .005" or .0063" while the conductor for overhead weatherproof cable may be a single wire.

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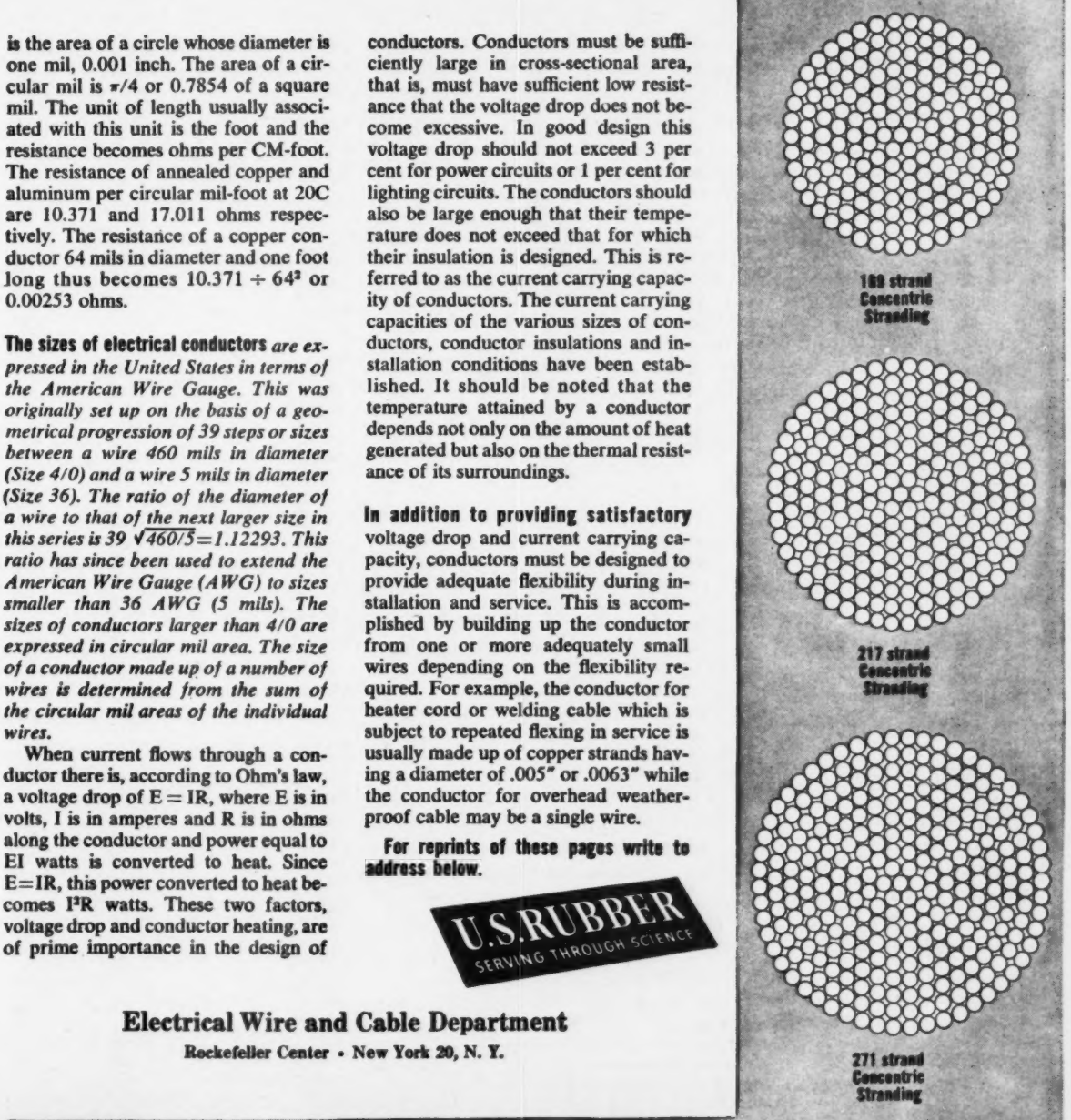


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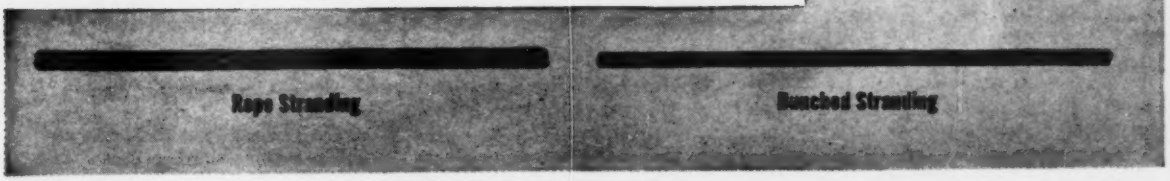


# What's Happening at CRUCIBLE

## about Alnico Permanent Magnets

You will find Crucible Alnico Permanent Magnets in products ranging all the way from cuff links to magnatrons. Here are just a few unusual applications in which these magnets were used to simplify or improve a product.

*This is Warren, age 4, a cerebral palsied youngster, using magnetic toys in therapy-play.*

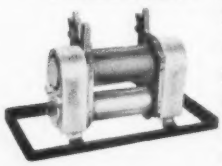
**Magnetic Toys** Cerebral palsied youngsters at the Children's Rehabilitation Institute, Cockeysville, Maryland, are unable to play with normal toys. Their lack of muscular coordination and control, causes ordinary blocks or toys to slip through their grasp and fall to the floor. Crucible helped overcome this problem by imbedding small permanent magnets in the toys. By using these magnet-equipped toys on metal topped tables, the children are able to control them much more easily.

The Children's Rehabilitation Institute has pioneered techniques to help these handicapped children gain maximum muscular control and coordination. Experience at the Institute has shown that the use of magnetized toys helps develop coordination in hand and arm use, and in grasping and releasing.

**Cuff Links** One manufacturer of cuff links had a happy idea. He replaced the stem with a magnet assembly designed by Crucible magnet engineers. The tiny, powerful aspirin-sized magnets used, gave the finished product a holding force at the pole plate as high as 80 ounces troy.

*Enlarged cross section view of one cuff link.*

**Telescriber-Recorder** In one application, for this instrument that transmits written messages over wire, two permanent magnets were being used to match the electromagnetic fields. Assembly time and unit costs were high. Crucible magnet specialists designed one permanent Alnico magnet to replace the two. Magnet costs were cut 50% . . . and efficiency of the unit was increased.



*Top bar Crucible Alnico; lower bar (replacing former 2nd magnet) provides return path.*

## Engineering Service Available

Perhaps your magnet problems are entirely different from these. Whatever they may be, our staff of magnet and electronic engineers will be glad to tackle them, and to work with you in meeting your magnet requirements. Don't hesitate to call us when you have an application for permanent magnets.

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# HOW TO DESIGN FOR LOWER STRUCTURAL COSTS

WITH today's accent on cost, there is a promising future for the designer who can simplify structural designs to save steel and construction manhours. Such savings are being realized every day by the use of arc welding instead of riveting in the construction of all types of industrial plants, multi-story buildings and bridges. By eliminating rivets and taking advantage of rigid framing and continuous beam construction, welded designs help to offset the rising costs in labor and materials.

Shown below is a typical example of how full structural continuity achieved through arc welding effected savings of $22,000 in the construction of an 87,000 square foot process warehouse. Arc welding actually has saved 1.68 pounds of steel per square foot. At $0.15 per pound for fabricated steel, the saving amounts to $22,000 over the cost of steel alone had riveted design been used.

In spite of the rapid progress made in the construction field by the welding industry, new developments are taking place every day which are of prime importance to the structural engineering graduate. Latest information on welded structural designs is available in handbooks and bulletins simply by writing to The Lincoln Electric Company, Cleveland 17, Ohio.

**Fig. 1. Process warehouse** *for the Hale-Halsell Grocery Co., Tulsa, Oklahoma. Size 250' x 350' with 16' clear height. Contractor: Tulsa Rig and Reel and Manufacturing Co. Consulting Engineer: David R. Graham & Associates, Tulsa, Oklahoma.*

**THE LINCOLN ELECTRIC COMPANY**
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THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

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The handful of Fafnir Ball Bearings illustrated, help to assure the success of an amazingly ingenious, 36 lb. Automatic Pilot and Approach Coupler for jet planes. These instrument bearings, 22 in all, weigh less than 4 ounces. Their compactness, extreme sensitivity and dependability are vital to the instrument system's design and performance. Fafnir Extra-Small Ball Bearings for extremely small shafts are available in various constructions and tolerances to meet exacting requirements. The Fafnir Bearing Company, New Britain, Conn.

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balt, manganese and other heavy metals. Before a test is made with the dithizone indicator, the element being tested is separated from the plant ash by any convenient chemical extraction process. The separated element, for instance copper, when allowed to react with a dithizone solution shows a distinctive blue color. The intensity of the coloring when compared by eye with solutions containing known amounts of copper will give the concentration of the copper within five per cent. The concentrations are measured in parts per million (ppm), an indication of the extreme sensitivity of the dithizone indicator.

Another analytical technique is spectrochemical analysis. It is more accurate than the dithizone method, but slower and less convenient. Since extreme accuracy is not important in the biogeochemical method, spectrochemistry has been little used up to now but it may find increased application as the accuracy of the entire method increases.

The data obtained from plant samples and their chemical analysis, when plotted on a map of the area being explored, results in what is known as an anomaly map. A map of this kind shows the above normal concentrations of an element in the soil. This usually indicates that an ore deposit lies under the anomaly. Since an ore body does not necessarily lie under a point where a large concentration of an element is present in the soil, the anomaly map requires interpretation. The geological interpretation of this map is based on past experience with biogecchemical surveys and on any geological data that may be available. The additional information may be obtained from aerail photographs, geophysical surveys, or nearby areas where the geology is already known.

As can readily be seen, the biogeochemical method of prospecting has several limitations. The greatest limitation is imposed by unmeasured factors controlling the concentration of the elements in the soil and in the plants. As the method is perfected, more and more of these factors such as rainfall, drainage, and pH of soil will be taken into consideration.

*(Continued on page 59)*

*Another page for* **YOUR BEARING NOTEBOOK**

## How to carry a floor charger's 12-ton overhung load

This floor charger charges and levels 12 tons at a crack in open hearth furnaces. The 12-ton overhung load and the terrific shock loads set up by the charging operation are carried by the peel shaft bearings. To take these loads and to keep the charger in top operating shape, design engineers specify Timken® tapered roller bearings.

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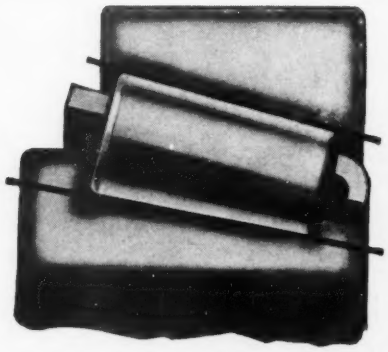

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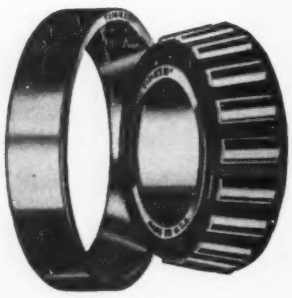
*TAPERED ROLLER BEARINGS*



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Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

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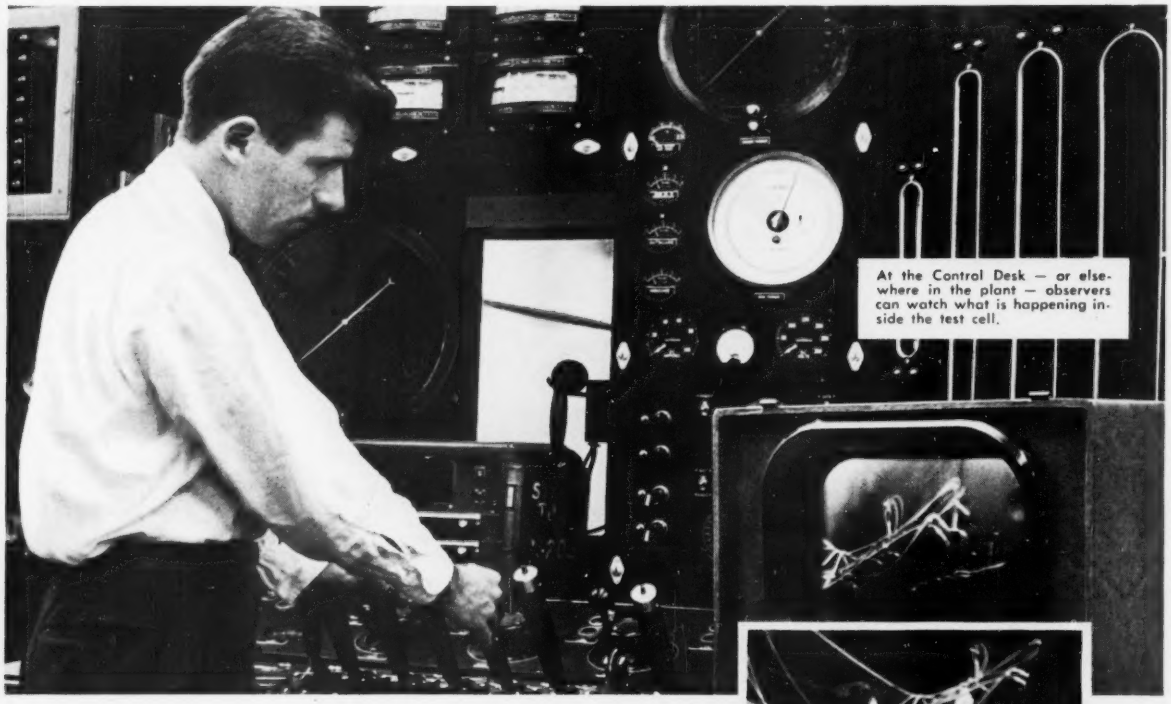
# NEW LOOK IN JET ENGINEERING



At the Control Desk — or elsewhere in the plant — observers can watch what is happening inside the test cell.

Television cameras are easily pre-focused on parts formerly impossible to see during a test run.

Through the use of industrial television, Pratt & Whitney Aircraft engineers can now watch what happens as big jet engines are run under abnormal conditions. Without personal hazard, they can see inside the test cell from any location in the plant.

On their television screens they can observe the action of linkages, controls and other parts. Even infra-red characteristics not visible to the human eye can be studied.

But to do this, many technical problems had to be solved. For instance, commercial equipment had to be modified in many ways to operate under abnormal temperatures and in hazardous atmospheres. Soon a further development will permit remote traversing of the camera and adjustment of lenses.

This typifies the way in which new engineering and research facilities are constantly made available to Pratt & Whitney Aircraft engineers. Here engineers are encouraged to experiment with new ideas — given an opportunity to do *real* engineering.

**PRATT & WHITNEY AIRCRAFT**
Division of United Aircraft Corporation
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**If you are interested in our employment opportunities for engineers, contact your College Placement Officer or write directly to Mr. Frank W. Powers, Engineering Department, Pratt & Whitney Aircraft, East Hartford, Conn.**

# anam imi una

By John Avery, '54

I have always rebelled against learning how to spell. Whenever anyone objects to my own original arrangement of letters in a word, I shout that I will some day have a secretary to take care of such matters. To further justify this point of view, I have always claimed that the letters which go to make up words have no meaning in themselves, and therefore the public school system has no right to force young people to learn them.

The logical thing is for everyone who shares this dim view of spelling (I assume that this includes most people) to get together and invent a language in which each letter is crammed with meaning, and therefore easily learned. Inventing a language from scratch gives us the right to choose our vocabulary in any way that we please. Let us build our language in such a way that two words which mean nearly the same thing will be spelled nearly alike. All nouns will begin with the same letter; all vegetable nouns with the same first two letters; all names of trees with the same first three letters, each consecutive letter defining a progressively more narrow class of objects. Listed below is a partial vocabulary:

FIRST LETTER

a—noun
e—adjective
i—verb
o—adverb
u—preposition or conjunction
k—interjection

SECOND LETTER

*following a*

m—vegetable
n—animal
r—mineral
l—abstract
b—man-made

*following e or o*

m—sensory
n—articles
r—categorical
l—physically limiting

*following i*

m—motion
n—sensation
r—function
l—existence

*following u*

m—position
n—direction to
r—direction from
l—conjunction

THIRD LETTER

*following am*

a—tree
e—parasites
i—food
o—flower
u—processed

*following an*

a—mammals
e—reptiles
i—insects
o—fish
u—birds
k—processed
t—microscopic

*following ar*

a—solid
e—liquid
i—gas
o—mixture

*following al*

a—moral and emotional
e—phenomenal
i—organizational
o—conceptual

*following um, un,* or *ur*

a—forward
e—backward
i—right
o—left
u—up
k—down
t—other

*following em* or *om*

a—eye
e—ear
i—nose
o—taste
u—touch
k—emotions

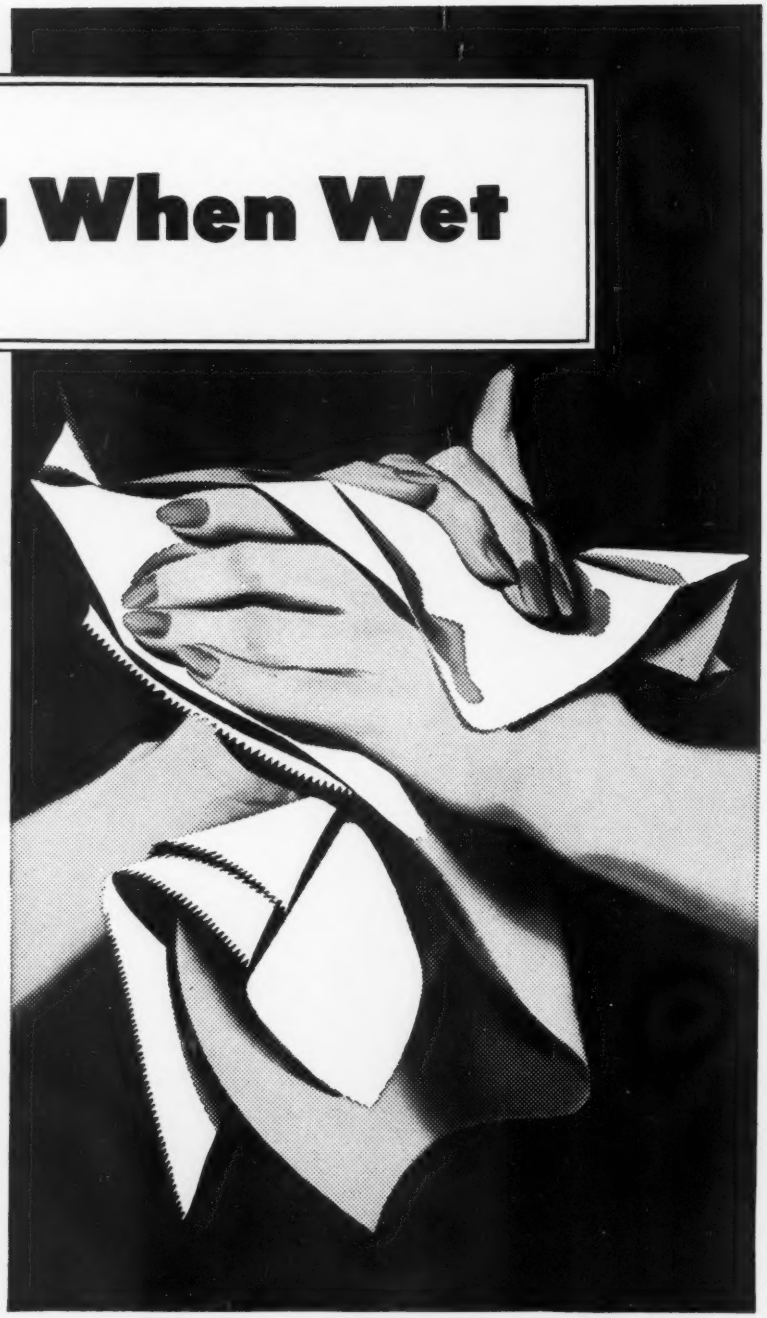
*following ab*

a—machine
e—edifice
i—commodity
o—article
u—other

*following er* or *or*

a—moral
e—phenomenal
i—organizational
o—conceptual

# Strong When Wet



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... paper that absorbs the maximum amount of moisture without falling apart.

**SOLUTION...**

... Kymene®, a series of wet-strength resins produced by Hercules for paper makers. Kymene-treated paper has excellent absorbency and wet-strength. Manufacturers, for example, find that the use of Kymene produces a vastly improved paper towel at remarkably little extra cost.

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**Hercules' business is solving problems by chemistry for industry...**

*... plastics, paint, varnish, lacquer, textiles, paper, rubber, insecticides, adhesives, soaps, detergents, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.*

HERCULES

*HERCULES POWDER COMPANY Wilmington 99, Delaware*
*Sales Offices in Principal Cities*

*following el* or *ol*
a—size
e—weight
i—shape
o—appearance
u—other
*following im, in, ir* or *il*
a—first person singular
e—second person singular
i—third person singular
o—first person plural
u—third person plural
*following ul*
a—and
e—but
i—because
o—therefore

FOURTH LETTER
*following ami*
m—fruit
n—vegetable
r—cereal
l—other
*following amu*
m—wood
n—paper
r—fabric
l—chemical
b—other
*following ana*
m—man
n—wild
r—domestic
*following ank*
a—food
e—fabric
i—leather
o—chemical
u—other
*following ala*
m—words which imply approval
n—words which imply disapproval

Only the first three letters are defined. A vocabulary which defined the first seven or eight letters could include every shade of meaning of all words in the English language.

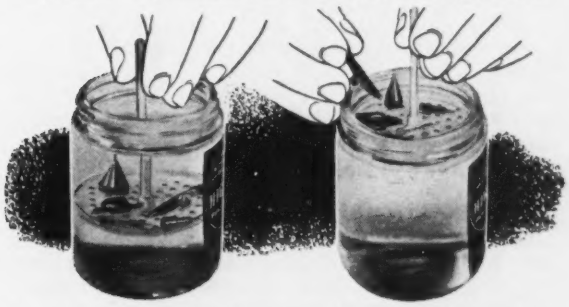
The steps taken in choosing *ele* as the first three letters of any physically limiting adjective having to do with weight are indicated in the above table. When we assign a fourth letter, it will differentiate between the different degrees of weight. For instance, *elem* might mean *heavy*, and *elen* might mean *light*. Notice that *olen* would then mean *lightly*.

There are two important advantages to this kind of language which I have not yet mentioned. First, one does not have to know the exact meaning of a word in order to know its approximate meaning. Secondly, the associations and categories intrinsic to the language are roughly parallel to those which must be formed by the synapses of the human mind. I believe that a language based on the principles outlined above could be learned more easily. Furthermore, it is easily adapted to the binomial system used in electro-mechanical storage devices.

If it is true that ease of learning is the greatest to this system, it is equally true that difficulty of use is its greatest disadvantage. A misprint (substitution, inversion or omission), especially at the beginning of the word completely alters the meaning of the word.


**for your added convenience . . . a handy new package for HIGGINS PEN CLEANER**

It would be difficult indeed to improve on the popular cleaner which makes all your pens and instruments better than new . . . but we now make it even easier for you to use!



A plastic strainer in each 6 oz. jar invites you to drop instruments and parts unconcernedly in cleaner.

Simply lift strainer to retrieve thoroughly cleansed instruments without soiling fingers and without clumsy fishing in jar.

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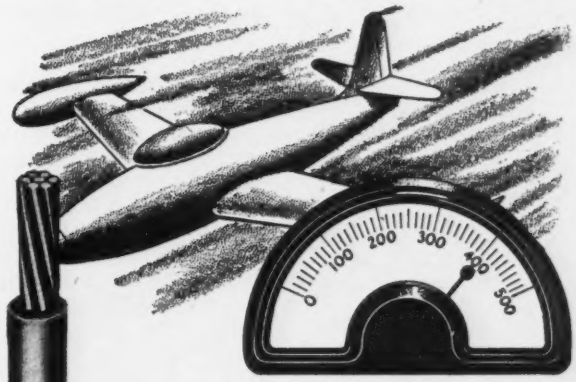


***In the development of a new jet engine,*** difficulty was encountered due to the intense heats. Since the engine generated temperatures as high as 400°F., even usual heat-resistant insulations on the ignition wires would not stand up.

Okonite researchers were consulted on the problem. Their investigations led them to recommend Okotherm, an insulation of remarkable heat-resisting qualities, made by Okonite. Okotherm retains its dielectric strength over an extremely wide range of temperatures, and was consequently the first electrical cable to gain approval for the new engine.

• • •

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE insulated wires and cables

# energy for life

*Photosynthesis: key to synthetic food?*

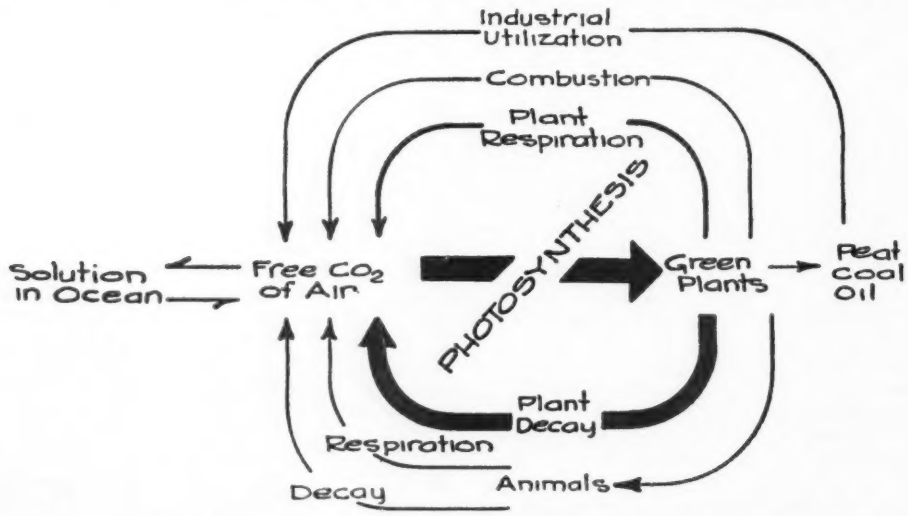
By Emmanuel P. Papadakis, '56

Since photosynthesis is of great importance to human life, it is both interesting academically and important practically to ask," What is photosynthesis?" "How does it work?" "Can we duplicate the process synthetically?"

For centuries men have been delving into natural philosophy to find answers to the questions of life and the universe, but only relatively recently have they been able to arrive at any useful conclusions about the material problems confronting them. A great progressive step will be taken when man no longer needs to rely on cultivated greenery to supply him with his food. This step will come only after men have been able to reproduce the process of photosynthesis without the help of any living organism. Much research with this end in view has been done already, and much more is in progress.

Historically, the world did not renounce the Aristotelian dictum that all plant nutrients came from the soil until von Helmont (1577-1644) showed in his classic experiment that a five-pound willow tree gained 164 pounds while the soil it was planted in lost only two ounces. Later work by Malpighi showed that leaves were necessary to plant growth. Hales (1677-1721) showed that part of the nourishment of the plant comes from the atmosphere through the leaves. Hales was probably the first to suggest that light affected plant growth, although he was not sure about the matter. Priestly and Scheele both did work on the subject and arrived at conflicting conclusions; the former found that plants took up "phlogisticated air" and gave off good "dephlogisticated air" (since Lavoisier had not yet disproved the phlogiston theory of combustion). Scheele found exactly the opposite result. The contradiction was resolved masterfully by Ingen-Houz by his experiments showing that plants give off what we know as oxygen during daylight and carbon dioxide at night, that only leaves do this, and that excess $CO_2$ concentration is poisonous even to plants. He also found that the rate at which oxygen was given off was related to the intensity of visible light and the concentration of $CO_2$. Soon after 1800 interest in the process of photosynthesis waned because of a shift of interest to work on classifying all the species of plants under Linnaeus's system. More recently interest in photosynthesis has been revived.

It is known that four constituents are necessary in order that photosynthesis may proceed; they are 1) light from the visible spectrum, 2) carbon dioxide from the air, 3) water, and 4) the green plant in which the process is carried out. It is convenient to postulate that the hexose form of sugar, $C_6H_{12}O_6$, is the main end product, and that other forms of sugar are made from it later by the plant. From the sugars are made starch, cellulose, and protein (with the assimilation of nitrogen), all of which are necessary for plant and animal life. The exact nature of the process by which the carbon dioxide and water are converted into hexose is still unknown, but from evidence gathered in recent research it seems that the main reaction may be written as




**—The carbon cycle. $CO_2$ is removed from the air by photosynthetic plants, and largely returned by the microscopic plants responsible for decay.**

follows:

$$6CO_2 + 12H_2O \xrightarrow{h\nu} C_6H_{12}O_6 + 6H_2O + 6O_2 \text{ (a)}$$

The twelve waters appear necessary from experimental data, although it is not definitely known whether the twelve are used and six recovered, or only six used as was earlier postulated. To fit the following theory, however, twelve are needed.

The $h\nu$ represents quanta of light energy from the visible spectrum; i. e., wavelengths of from 4000 to 7000 Angstroms. It is known that 6000 A. is fully capable of actuating photosynthesis. From considerations of the heat of combustion of glucose and the energy carried by a quantum of light at 6000 A., there should be at least three quanta needed to convert one molecule of carbon dioxide to one $CH_2O$ (formaldehyde). Because of the possibility of wasted energy and further considerations, the minimum number of quanta necessary is held to be four. From equation (a) it can be seen that four atoms of hydrogen are engaged for every atom of carbon in the reaction; one $C^{+4}$ in $CO_2$ is reduced to $C^{\circ}$ in $CH_2O$. This supports the conclusion that four quanta are necessary. It seems that the $6O_2$ on the right side of equation (a) come from $12H_2O$ on the left side, and that the six oxygens in the remaining water on the right side come from the $6CO_2$. These conclusions are supported by the fact that hydrogen gas serves as well as water to supply the hydrogen for reducing the carbon, giving the equation:

$$6CO_2 + 12\ H_2 \xrightarrow{h\nu} C_6H_{12}O_6 + 6H_2O$$

In equation (a) the following steps might take place:

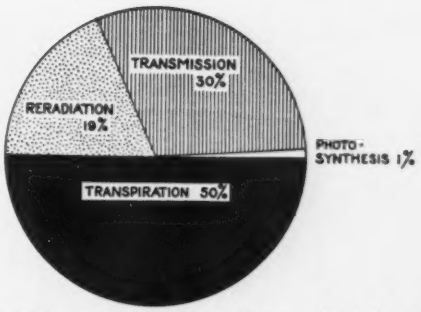
Four quanta of light might split $2H_2O$ into $4H^{\circ}$ and $O_2^{\circ}$. Then

$$4H^{\circ} + CO_2 = C^{\circ} + 4H + 2O = CH_2O + H_2O$$

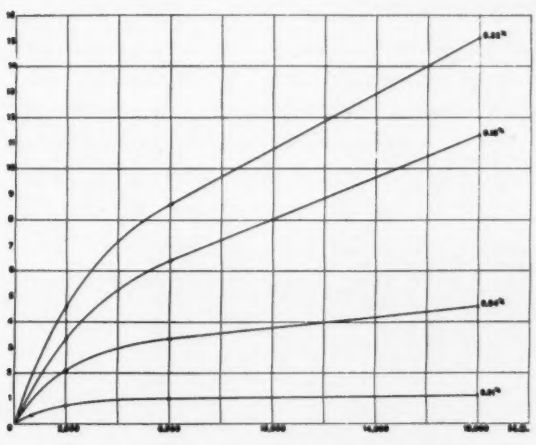
The reaction should go in four steps, one quantum transferring one H at a time. Thus several intermediate products would be formed and the reaction might be reversed if the conditions were right.

We have said that four quanta are necessary to convert each carbon in carbon dioxide to $CH_2O$, giving a quantum efficiency of 0.25 atoms/quantum. It has been found by experiment, however, that the efficiency under optimum conditions is about 0.10 or 0.125 showing that a minimum of two quanta are needed in conjunction with each transfer of hydrogen. Since it is known that the process of photosynthesis occurs only within the chloroplasts, or integral parts of the leaf cells containing chlorophyll, the hythepothesis follows that one quantum might be used to transfer the hydrogen to the chlorophyll as a "middle man" or catalytic agent, and a second quantum to transfer the hydrogen to the $CO_2$ molecule. It is thought that the chlorophyll absorbs the radiant energy and uses its raised energy level to remove the hydrogen from the water (or from the $H_2$ molecule if the gas is used) and then uses the rise in energy from the second quantum to deposit the hydrogen with the $CO_2$, reducing the carbon. Finally the six-carbon string of glucose is formed.

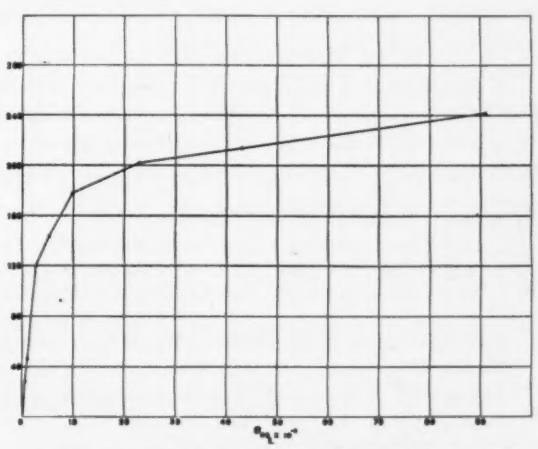
The foregoing is essentially the theory of the process of photosynthesis as it stands today. Obviously much more work must be done on the subject before man can bypass plants in making food for himself.




—What happens to solar radiation incident on a chlorophyllous leaf. The values indicated give approximate disposal of the energy; the ratio varies with changes in external conditions.



—Effect of change in light intensity on the rate of photosynthesis of *Fontinalis* with different concentrations of carbon dioxide. (From Harder.)



—The rate of photosynthesis at different concentrations of carbon dioxide. The ordinate represents the rate of photosynthesis, the abscissa the concentration of carbon dioxide. (Constructed from values given by Warburg.)

# William R. Parlett, Cornell '48, Sets Sights on Executive Sales Job

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"I have found that with Worthington you have job satisfaction, adequate compensation, and unlimited opportunity."

When you're thinking of a good job, think *high*—think *Worthington.* 3.6

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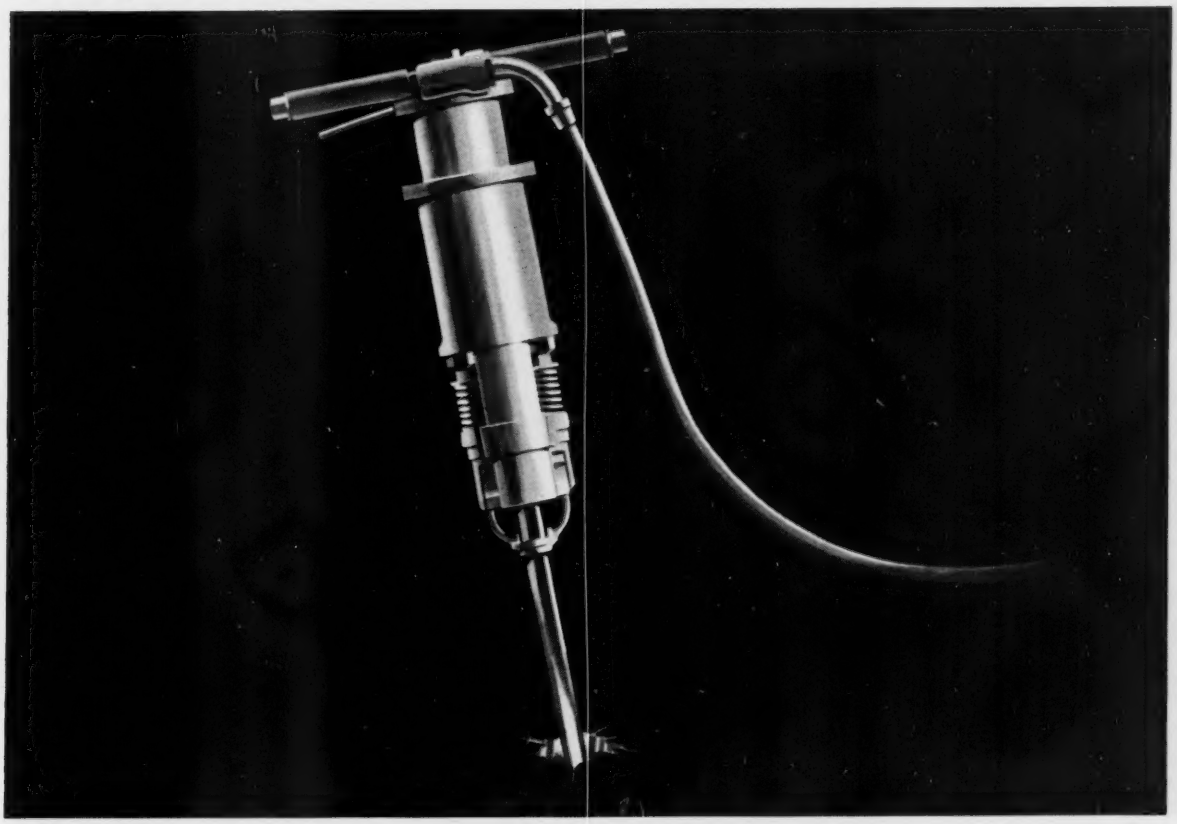

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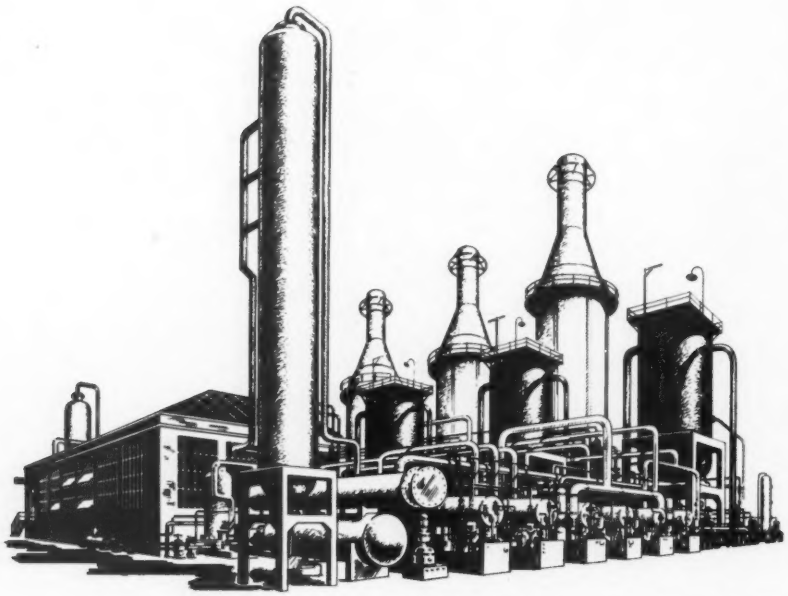
# the big cats

By Tom Cantrell, '55



## *Introduction*

The most prominent feature in any oil refinery skyline is the towering "cat" crackers. In this article we shall try to develop just what these units are, what they do and why they are so important.

To begin with, the refining processes used before the advent of catalytic cracking must be reviewed. Crude oil is a mixture of hydro carbons of organic origin. The different compounds may be separated by selective distillation. This is a quite highly developed process called *Fractional Distillation*, which separates the crude into gasoline, kerosene, gas oil, and residual oil. However, the amount of gasoline which can be obtained from a barrel of a given crude is limited by the amount of gasoline the crude contains. This doesn't sound like a very profound statement, but it has very profound economic implications. For every barrel of gasoline obtained from a crude, there may be two of black fuel oil. While the one barrel of gasoline might be easy to sell, it might be much harder to sell twice that much bunker fuel.

That is the problem attacked by *Thermal Cracking*. In this process gas oil is subjected to heat and pressure which causes the heavy hydro carbons to break up into the lighter compounds of gasoline, hydrogen, and the light gases. Gasoline obtained by this method is of much better quality than straight-run gasoline from the fractional distillation towers. Thus the heavy, hard to sell fuel stock is chemically converted into gasoline which is in economic demand. Now the percentage of gasoline obtained from a barrel of crude is raised.

This was more or less the state of the industry until the late 'thirties, when a basically new approach was made.

*Catalytic Cracking* consists of using a catalyst to cause the cracking reactions to go. The standard definition of a catalyst is "something that makes a reaction go without taking part in it." It is to be emphasized that the catalyst does not merely catalyze the thermal cracking reactions; rather the catalyst causes an entirely different set of reactions, with different end products. These products are of higher quality than those yielded by thermal cracking. The catalyst becomes contaminated, and must be regenerated.

Like all engineering processes, catalytic cracking has passed through several stages of development. There have been developed four principal processes which we shall inspect individually: Houdry fixed bed, Thermofor moving bed, fluidized catalyst, and suspensiod.

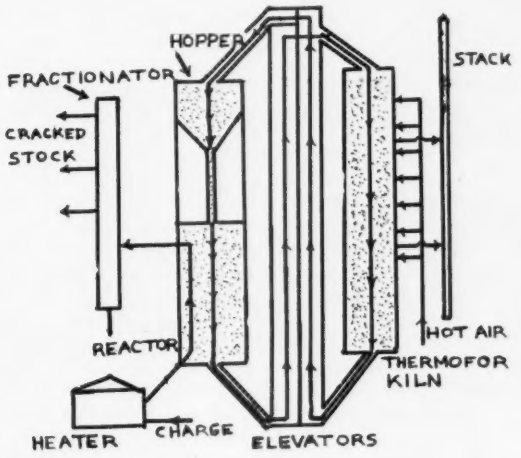
## *Houdry Fixed Bed Cracking Units*

Eugene Houdry began work on a catalytic cracking method in 1924, in France. In this country, Houdry received the support of the Socony-Vacuum Company, and the Sun Oil Company. The first pilot plant was built in 1930, and the first commercial unit, with 2000 barrels per day capacity began operation at Paulsboro, N. J. in 1936.

In the Houdry process, the catalyst is a pelleted aluminosilicate, stored in large cylindrical cases. The feed stock vapors enter the case at the bottom and leave it through the top. As they pass through the catalyst bed the heavy oil is "cracked" into lighter products. The operation takes place at 900 degrees F. and at a pressure of 30 psi. The catalyst meanwhile becomes covered with coke, which reduces the activity of the catalyst.

This contamination of the catalyst necessitates "Regenerating" the catalyst, which is the other major step in the process. This is done by cutting off the feed stock flow after ten minutes, blowing steam through the case for five minutes, and then blowing air through the case for ten minutes to burn the coke off the catalyst. After this, inert gas is blown through, and the feed stock stream is passed through the case again. The complete cycle in a typical plant takes thirty minutes.

In order to have continuous operations, a battery of three such cases is used. It requires very careful control to maintain continuous operations by timing and coordinating the cycles of the cases.




Thermofor catalytic cracking unit.

One of the most critical factors to control within the catalyst cases is the temperature. The burning off of the coke during the regenerating stage is of course exothermic, while the actual cracking is endothermic. The temperature is controlled by tubes of molten salt passing through the cases. The salt used is a mixture of $KNO_3$ and $NaNO_2$. It is used to remove heat from the cases at the regenerating (coke burning) stage, and supply it to those cases in the group at the cracking stage.

The cracked vapors after leaving the catalyst case are passed into a conventional fractionating tower where they are separated.

The fixed bed cracking system described above has several inherent advantages and disadvantages. Among the advantages are: small loss of catalyst, simplicity of separating oil from catalyst, and flexibility of operating pressures. The disadvantages are: difficulty of adding or removing catalyst, poor heat transfer characteristics, and the difficulty of complete "purging" by steam

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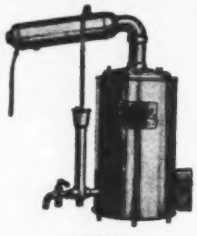

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and inert gas, between cracking and regenerating stages. These inherent difficulties led to a search for a continuous, moving bed process.

## *Moving Bed Cracking Units*

The first moving bed Thermofor Catalytic Cracking Unit was put to work in 1943 at the Beaumont, Texas, Refinery of the Magnolia Petroleum Company. The thermofor process does the same thing, basically, that a Houdry unit does: cracks the feed stock by passing it through the catalyst, and regenerates the catalyst by burning off the accumulated coke. The *big* difference is that the two steps are carried out simultaneously, in separate vessels, making the whole process continuous.

The cycle of operations in the early thermofor units was: Catalyst pellets were fed continuously from a storage hopper through a long seal leg into the top of the reactor, where they flowed downward. The operating temperature in the reactor was 850-950 degrees F. The feed stock vapor entered the bottom and the cracked vapors left the top of the reactor. The catalyst thus flowed downward countercurrent to the gas flow. The spent catalyst was drawn out at the bottom of the reactor, and carried by bucket elevator to the top of the thermofor kiln for removal of the carbon.

The kiln is a vertical cylinder made up of a set of burning zones, where air is blown through and alternate cooling zones where water coils surround the kiln. Steam, of course, is generated in these coils, and is added to the refinery steam supply. This zone type construction provides more thorough removal of water and sulfur oxides from the catalyst. The regenerated catalyst leaves the kiln at the bottom and is carried by bucket elevator to the storage hopper at the top of the unit.

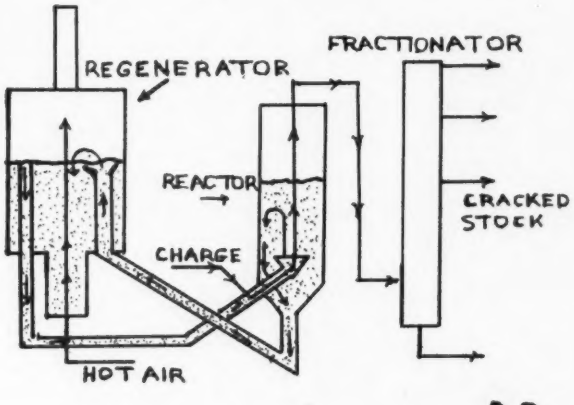
In this kind of unit where the catalyst flows through pipes, and is carried in bucket elevators, a catalyst that will not powder easily is obviously needed. Socony Vacuum developed a bead catalyst which is excellent in this respect.

In later units the bucket conveyors were replaced by an air lift, in which the catalyst was blown up a pipe by an air stream, eliminating a major source of wear.

Two other modifications are liquid charging and concurrent flow. By adding a mixture of liquids and gases at the top of the reactor, and allowing them to flow downward with the catalyst several advantages are gained. The main one is better utilization of the heat content of the catalyst.

The Houdriflow Process uses the same principles as the conventional thermofor units, but the arrangement is more efficient. The reactor is placed directly above the regenerator kiln. Feed stock is fed into the top of the reactor, so there is a concurrent flow. The regenerated catalyst from the bottom of the kiln is carried to the top of the unit by a flue gas lift.

The fluidized catalyst cracking units are today the most numerous and most important type of




Fluidized bed catalytic cracking unit.

cat crackers. Much of the early development work on the process was done by the Standard Oil Development Company. Over five million man hours were spent in research, development, and engineering in the ten years which preceeded the construction of the first unit in 1941.

The heart of this process is the fluidized catalyst bed. In the previous processes the catalyst bed was made up of granular solids. In the Houdry process they remained stationary in the catalyst cases. In the thermofor process they moved, but they nontheless behaved as solids. In fluidized process, by using a very fine catalyst and mixing it with gas, there is obtained a mixture having many properties of a *fluid*. This air-solid mixture is called a pseudoliquid. When the flow of gas through the solid catalyst is properly adjusted, the individual solid particles are airborne, but they remain closely packed, giving an overall behavior of a liquid. Since the catalyst can now be made to behave like a liquid, the awkward mechanical handling equipment of the thermofor units can be replaced by piping.

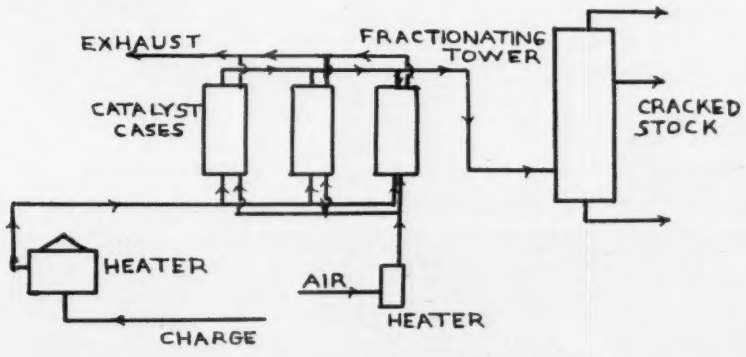
The original fluidized units were of the upflow design, in this process, hot powdered catalyst is fed into the cold feed stock, vaporizing it. This forms the pseudoliquid described above. It is passed into the reactor, where the feed stock is cracked into gasoline, fuel oil stock, gas oil, and bottoms. These vapors and the catalyst pass out of the top of the reactor, and into a cyclone separator. Here the vapors are separated from the catalyst, and led to a fractionating tower.

The spent catalyst is fed from the separator into an air stream, forming another pseudoliquid which flows into the regenerator kettle where the coke is oxidized off. The flue gases and catalyst pass out of the top of the regenerator, and into another cyclone separator where the catalyst is separated out and fed back into the feed stock line.

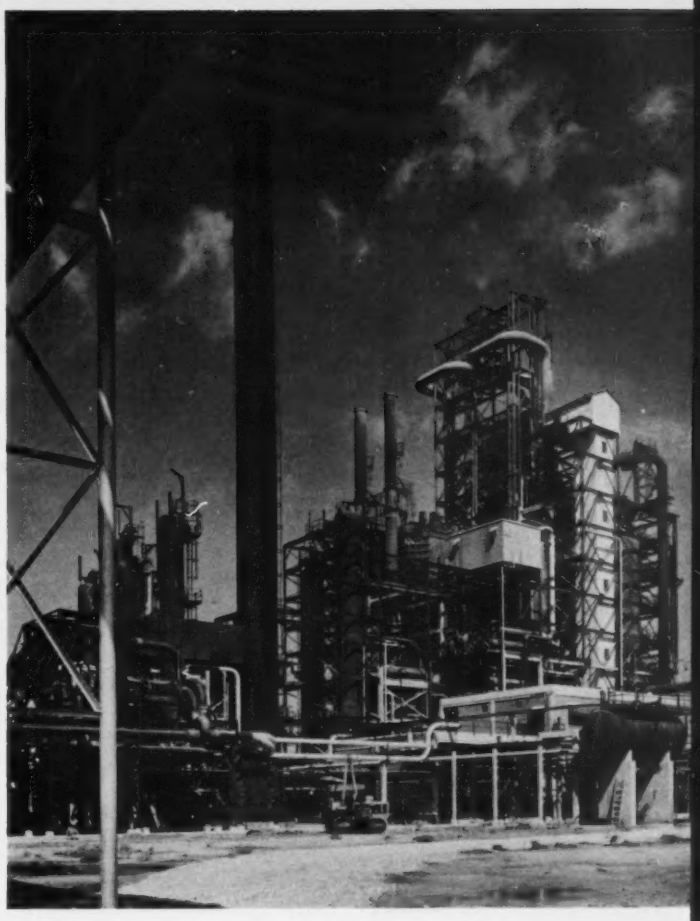
This process is free from the cycle complexities of the Houdry process and the mechanical handling problems of the thermofor process, but it has one great weakness. That is that the catalyst must be separated from gas streams in cyclone units at two points in the process. To get around this procedure, another approach was made, and the downflow process was evolved. This is the process used, with refinements, in the newest units.

In the improved downflow process, the hot catalyst is fed into the feed stock, vaporizing it, just as in the upflow process. However, the rate of flow is slower so that when the pseudoliquid enters the reactor, it is not swept up through the reactor and into the cyclone separator. Rather, it forms a pool in the reactor which resembles a violently boiling liquid. The cracked vapors are thus disengaged from the catalyst right in the reactor, eliminating the need for large separators. Again, the vapors are led to fractionating columns. The spent catalyst is drawn off from the pool in the reactor, and fed into an air stream which carries it to the regenerator where another boiling "pool" is formed while the coke is burned off the catalyst. The regenerated catalyst is drawn off this pool and fed back into the feed stock line.

The Universal Oil Products Company has pioneered the development of small fluidized cracking units. These differ from the Standard Oil Development Company "school of design" principally in arrangement of equipment. In the newest units, the reactor is placed directly above the regenerator, simplifying the supporting structure considerably.




Houdry catalytic cracking unit.



Thermofor catalytic cracker.

### *The Suspensoid Process*

The last process we shall inspect is the Suspensoid process developed by the Imperial Oil Company of Canada. This process is really a compromise between conventional thermal cracking and catalytic cracking. In this respect it is not an out growth of the original Houdry process, as the other processes are. In this process, small amounts of catalyst are fed into the charging stock on the way to a thermal cracking tower. The catalyst used is usually waste clay from lube oil treating plants, so there is no regeneration. The catalyst collects in the heaviest cuts, from the cracking tower, and is separated from them in a rotary filter.

### *Conclusion*

Catalytic cracking promises to be the dominating refining process in the years to come. It is expected that eventually it will will completely replace thermal cracking. It was instrumental in the winning of the Second World War, since the Allies had a source of high quality aviation gasoline in large quantities. Catalytic cracking has been rightly called "the largest single stride in the development of refining processes that the petroleum industry has ever made."

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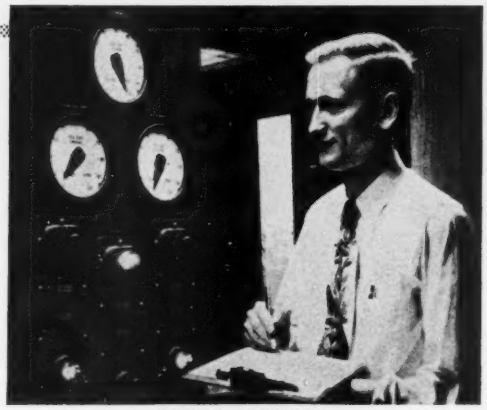

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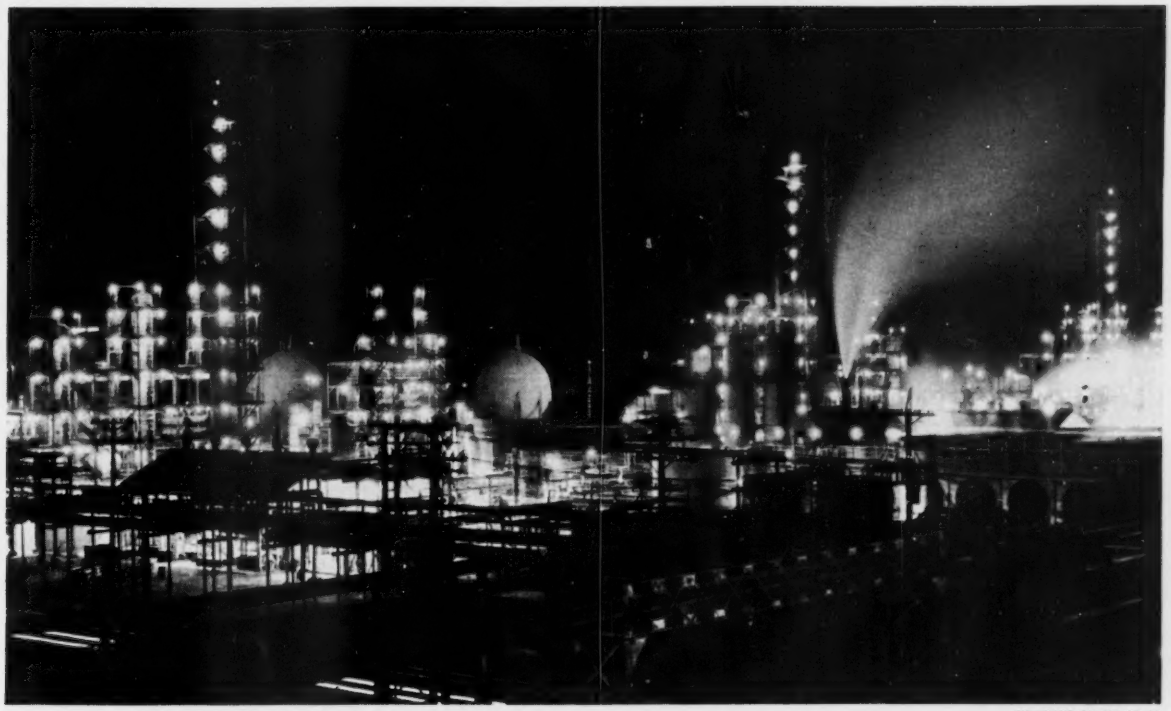

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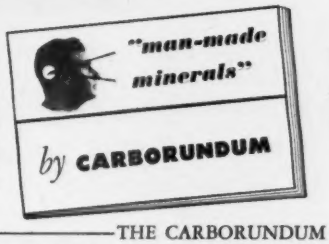


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# some diophantine problems

By Thomas Knapp, '54

In this paper the solutions to several problems, which are among the curiosities of mathematics, will be presented. While these problems are of certain interest for their own sakes, they have no practical importance; nor do their solutions cast any light upon other mathematical questions.

These problems are of one general type. There are equations which may be solved quite easily, if no restrictions are placed on the solutions. However, if it is required that the solutions belong to a special class of numbers, the problem of solving a given equation becomes more difficult, if not impossible.

In the following examples the requirement that a solution be rational will be imposed. However, the method is substantially the same for all restrictions: the substitution of new variables for the original variables. For example, in the substitution

$$a_1 x_1 + a_2 x_2 = z_1$$
$$a_1' x_1 + a_2' x_2 = z$$

where the a's are rational, $z_1$ and $z_2$ are rational if $x_1$ and $x_2$ are rational, and conversely, $x_1$ and $x_2$ rational if $z_1$ and $z_2$ are rational.

Consider the equation

$$nx_1^2 + 1 = x_2^2 \qquad (1)$$

where n is rational. To obtain rational values of $x_1$ and $x_2$, it is assumed that $x_1$ is related to $x_2$ by

$$px_1 + 1 = x_2 \qquad (2)$$

where p is rational. Clearly, any two rational numbers can be written in this way, by appropriate choice of p, so that there is no loss of generality. Equation (3) becomes

$$nx_1^2 + 1 = (p x_1 + 1)^2 = p^2 x_1^2 + 2px_1 + 1$$

and

$$nx_1^2 = p^2 x_1^2 + 2px_1$$
$$nx_1 = p^2 x_1 + 2p$$
$$x_1 = \frac{2p}{n-p^2}$$

If there exist rational $x_1$ and $x_2$ satisfying equation (1) for a given n, and if

$$p = \frac{x_2 - 1}{x_1}$$

implying

$$x_2 = p x_1 + 1$$

then, it has been shown that

$$x_1 = \frac{2p}{n-p^2} \qquad (3)$$

If, on the other hand, an arbitrary rational number, p, is chosen, and $x_1$ is set equal to $\frac{2p}{n-p^2}$, then

$$(n_1 - p^2)\, x_1 = 2p = nx_1 - p^2 x_1$$
$$nx_1 = p^2 x_1 + 2p$$
$$nx_1^2 = p^2 x_1^2 + 2px_1$$
$$nx_1^2 + 1 = p^2 x_1^2 + 2px_1 + 1$$
$$(px+1)^2 = x_2^2$$

Thus, the derivation has been retraced in the opposite direction, and it has been shown that two rational numbers, $x_1$ and $x_2$, are solutions of equation (1) if, and only if, they satisfy equations (2) and (3); that is, we have found all possible rational solutions of equation (1).

If n is an integer, the solutions can be further restricted, so that $x_1$ and $x_2$ must also be integers. The solution just derived is useless, since it is difficult to find a rational value of p such that $x_1$ and $x_2$ will satisfy equations (2) and (3). This problem involving integers has been solved completely, but the solution is rather complicated and will not be dealt with here.

It has been proved impossible to find rational x, y, and z satisfying the equation

$$x^3 + y^3 = z^3$$

It is, however, possible to solve

$$w^3 + x^3 + y^3 = z^3$$

for rational solutions. For example,

$$3^3 + 4^3 + 5^3 = 6^3$$

In fact, let z and w be any rational numbers, a and b respectively, and it is possible to find x and y satisfying

$$b^3 + x^3 + y^3 = a^3 \qquad (4)$$

In the first example the substitution was arranged to eliminate the constant, 1; in this example the elimination of the constant, $a^3$—$b^3$, will be accomplished by the following substitution:

$$x = a - z \qquad (5)$$
$$y = m z - b \qquad (6)$$

Thus, it is now necessary to determine m and z, instead of x and y.

$$a^3 - b^3 = x^3 + y^3 = (a-z)^3 + (m z - b)^3$$
$$m^3 z^3 - 3m^2 z^2 b + 3mzb^2 - b^3$$
$$a^3 - b^3 = a^3 - 3a^2 z + 3az^2 - z^3 +$$
$$0 = z\,(3mb^2 - 3a^2) + z^2\,(3a - 3m^2 b) + z^3\,(m^3 - 1)$$

Clearly, this last equation is equivalent to equation (4), since given x and y, it is possible to find m and z, or given m and z it is possible to find x and y. Although the derived equation cannot be solved in general, it is possible to obtain one solution. Let

$$m = a^2/b^2$$

Then

$$z\,(3mb^2-3a^2) = 0$$

and equation (7) becomes

$$z^2\,(3a-3\,\frac{a^4}{b^3}) + z^3\,(\frac{a^6}{b^6} - 1) = 0$$

Multiplying this by $\frac{b^6}{z^2}$, gives

$$3ab^6-3a^4b^3 + z\,(a^6-b^6) = 0$$

so that

$$z = 3ab^3\,\frac{a^3-b^3}{a^6-b^6} = \frac{3ab^3}{a^3+b^3}$$

From equations (5) and (6), x and y are obtained.

$$x = a - z = \frac{a^4-2ab^3}{a^3+b^3}$$

$$y = mz-b = \frac{2a^3b-b^4}{a^3+b^3}$$

The solution of

$$3^3 + x^3 + y^3 = 5^3$$

by means of the formulae given yields

$$x = \frac{355}{151} \quad ; \quad y = \frac{446}{151}$$

However, it is already known that x=3 and y=4 is solution. Thus, it is certain that the formulae derived do not give all possible solutions. Again, it should be noted that a complete solution has been found, but it is too long to be presented here.

Consider, now, a whole class of equations: those which can be put in the form

$$c_1x_1^{r_1} + \ldots + c_nX_n^{r_n} = d_1z_1^{q_1} + \ldots + d_mz_m^{q_m} \qquad (8)$$

where the c's and d's are rational, the r's and q's are positive or negative integers, and the products, $R=r_1r_2r_3r_4 \ldots r_2$ and $Q=q_1q_2q_3q_4 \ldots qm$, have no common divisors. Rational values of $x_1, x_2, x_3, \ldots, x_n$, and $z_1, z_2, z_3, \ldots, z_m$ satisfying equation (8) are sought.

Since Q and R have no common divisor, except 1, it can be shown that there exists integers, s and t, such that

$$sQ = tR + 1$$

Let

$$x_1 = P_1y^{\frac{sQ}{r_1}}$$
$$\vdots$$
$$x_i = P_iy^{\frac{sQ}{r_i}}$$

and let

$$z_1 = K_1y^{\frac{tR}{q_1}}$$
$$\vdots$$
$$z_j = K_jy^{\frac{tR}{q_j}}$$

These substitutions are valid, since the rationality of y, P, and K imply the rationality of x and z. After substitution, an equation in $y \ldots; P_1, \ldots, P_n$; and $K_1 \ldots, K_n$ is obtained. The new equation contains one more variable than the original but is more easily solved.

$$y^{sQ}\,(C_1P_1^{\frac{sQ}{r_1}} + \ldots + c_nP_n^{\frac{sQ}{r_n}}) = y^{tr}\,(d_1K_1^{\frac{tr}{q_1}} + \ldots + d_nK_n^{\frac{tr}{q_n}})$$

But

$$sQ = tR + 1$$

Dividing both sides of the equation by $y^{tR}$ gives (9)

$$y\,(C_1P_1^{sQ/r_1} + \ldots + C_nP_n^{sQ/r_n}) = d_1K_1^{\frac{tR}{q_1}} + \ldots + d_nK_n^{\frac{tr}{q_n}}$$

All possible solutions of equation (9) may be found by giving $P_1, \ldots, P_n$ and $K_1, \ldots, K_m$ arbitrary rational values and then dividing to find y. Since all possible solutions of the derived equation have been found, the complete set of solutions to the original equation has also been found.

As an example, consider

$$z\,X_1^2 = z_1^5 + 3z_2^3$$

Here, R=2, Q=15, and sQ=15, tR=14. Set $x_1 = P_1y^7$, $z_1=k_1y^3$, and $z_2=K_2y^5$. Substituting these values in equation (10) gives.

$$2P_1^2y^{14} = K_1^5y^{15} + 3K_2^3y^{15}$$

Dividing both sides by $y^{14}$,

$$2P_1^2 = y\,(K_1^5 + 3K_2^3)$$

Then

$$y = \frac{2\,P_1^2}{K_1^5+3K_2^3}$$

Take rational values of $P_1$, $K_1$, $K_2$ at random. From equation (11),

(10)

$$K_1^5y + 3K_2^3y = 2P_1 \qquad (11)$$
$$\vdots$$
$$K_1^5y^{15} + 3K_2^3y^{15} = 2Ry^{14}$$

So

$$(K_1y^3)^5 + 3(K_2y^5)^3 = z(P_1y^7)^2$$

$$2x_1^2 = z_1^5 + 3\,z_2^3$$

Therefore, equation (10) has been solved.

Many other such indeterminate equations may be solved, or at least simplified, by properly chosen substitutions.

# Midget with the giant brain

*The Problem*

*To design and build a computer for airborne automatic control systems—with severe restrictions imposed on size, weight and operation under extreme environmental conditions; in short, a computer that would be small, simple, reliable, rugged—and easy to build and maintain.*

**AT HUGHES RESEARCH** and Development Laboratories this problem was examined exhaustively, and it was concluded that a digital computer offered the best means for satisfying the requirements because of its ability to solve complex problems accurately and quickly.

Because the requirements of this application could not be met by existing digital computers, owing to their large size, the following developments were undertaken:

**1.** Simplification of the logical structure of the computer through the use of a mathematical theory of computer design based on Boolean algebra—but with retention of the operational versatility of a general-purpose computer.

**2.** Development of ingenious circuitry to utilize the new logical designs.

**3.** Achievement of minimum size by the use of subminiature techniques, including germanium diodes, subminiature tubes, and etched circuits.

**4.** Employment of unitized construction: plug-in units of flip-flop circuits and diode networks.

Need for subminiaturization, then, was a governing factor. Consequently, entire new techniques for making things not only vastly smaller, but at the same time easier to build and service, were developed by Hughes. This is a continuing process and there is indication of even more significant advancement in miniaturization for the future.

A major effort at Hughes is also devoted to adapting electronic digital computer techniques to business data processing and related applications—destined for far-reaching peacetime uses.

One of the subminiature switching circuits from the Hughes airborne electronic digital computer is examined by Dr. Eugene M. Grabbe (right), Associate Head, Computer Systems Department, Advanced Electronics Laboratory, and Phil A. Adamson of the Technical Staff, Radar Laboratory.

**ENGINEERS AND PHYSICISTS**

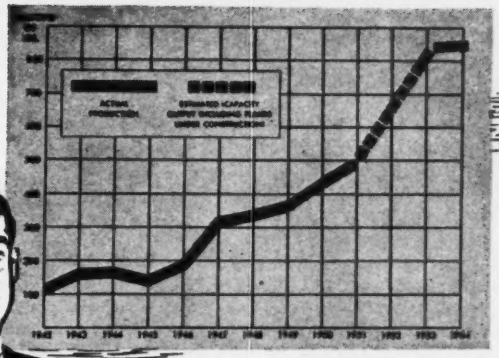
*Activities at Hughes in the computer field are creating some new positions in the Laboratories. Experience in the design and application of electronic digital computers is desirable, but not essential. Engineers and physicists with backgrounds of component development or system engineering are invited to apply.*

**ADDRESS:** *Scientific and Engineering Staff*

Hughes

**RESEARCH AND DEVELOPMENT LABORATORIES**

*Culver City, Los Angeles County, California*

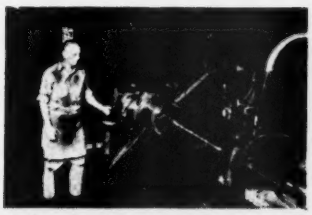


Reynolds expanding production —historic chapter in 33 years of continuing growth.

# A Fertile Place for Careers to Grow...



Settling tanks, where impurities are separated from sodium aluminate



Tube drawing, one of many mill operations at Reynolds

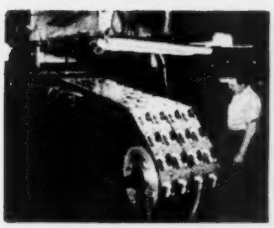
A broad vista of opportunity opens up for college graduates who come to work for Reynolds. The phenomenal rise of the Reynolds Metals Company, known throughout business and industry, is clearly depicted by the above chart. The five-fold expansion in total production of aluminum ingot alone spells broad opportunity. Add to this the vast and productive fabricating facilities of Reynolds —in themselves an enterprise of considerable proportions—and here indeed is a fertile field for any ambitious engineer.

From bauxite mining through metals refining and fabrication to application engineering, sales and marketing, Reynolds offers broad career opportunities. Operating 27 plants in 13 states, and still expanding, there is virtually no limit to what can be accomplished by a capable graduate engineer.

Preliminary orientation in production and sales...direct on-the-job training...liberal insurance, hospitalization and retirement programs...these are all parts of a sound personnel policy maintained at Reynolds.

For important information on "your future in Aluminum," *mail the coupon.* If you are definitely interested now, write direct to General Employment Manager, Reynolds Metals Company, 3rd and Grace Streets, Richmond 19, Va.

# REYNOLDS ALUMINUM



Foil—for many uses, including colorful, protective packages and labels; also famous Reynolds Wrap.

Full color movies tell the fascinating story of Reynolds Aluminum. 16mm films available for group showings.

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**Employment Dept.**
**Richmond 19, Virginia**

Please send me, **FREE,** your 96-page booklet "The ABC's of Aluminum"; also the 44-page book, "Reynolds Aluminum ... and the Company that makes it."

**Name**_____

**Address**_____

**School**_____ **Class**_____ **Course**_____

# briefing the news

### *Disconnect Switch*

The largest disconnect switch ever built is being prepared for a test in a high voltage laboratory. The switch is more than 17 feet long at the base and 25 feet high when in the full "open" position. The engineers who designed it say the switch is capable of handling 330-kv and of withstanding a power surge, such as might be caused by a lightning stroke of 1.3 million volts. The device can be operated manually or by an electric motor and will be used on high voltage utility circuits for isolating other electrical equipment to permit inspection and maintenance in complete safety.

### *Exhaust Gas Muffler . . . . .*

The operation of gasoline-driven equipment in enclosed and unventilated areas has been made completely safe by a muffler to "take the sting out" of exhaust gases. This is accomplished by oxidizing the dangerous and irritating fumes to carbon dioxide and water vapor, thus removing noxious carbon monoxide and hydrocarbon vapors.

The heart of the system is a cartridge of spaced porcelain rods coated with a catalytic agent. As the engine exhaust flows across the surface of the rods, combustion of carbon monoxide and other harmful vapors takes place. Only slight traces of the contaminants may be found in the final exhaust, which contains mostly the carbon dioxide and water vapor.

Exhibited for the first time at a national trade show, the muffler can be used on any engine that runs on liquid propane gas, diesel oil, or unleaded gasoline. Mobile, as well as stationary engines may be equipped with the muffler.

Out on the job . . . irrespective of your engineering role . . . you'll be coming to grips with the problem of eliminating wasteful friction.

You can look to SKF for the practical solution to anti-friction bearing problems.

SKF makes all of these eight types of bearings which serve virtually every equipment need. Rely on SKF for *putting the right bearing in the right place.* 7417

**SKF INDUSTRIES, INC.,** PHILADELPHIA 32, PA.
*—manufacturers of* SKF *and* HESS-BRIGHT *bearings.*

SKF
BALL AND ROLLER BEARINGS


Model car equipped with experimental electronic equipment is shown stopping itself to prevent a collision. Designed to study electronic control of automobiles on superhighways, the car at the rear picks up a warning signal set off by the parked car in front. Oscilloscope pattern at right of each picture shows how the warning signal received in the rear car gets stronger as it nears danger point.

### *Sleep While You Drive?*

How can electronics be used to reduce highway disasters and to relieve drivers of tiresome tasks on modern superhighways? This has been the subject of a study by Dr. V. K. Zworykin, pioneer television and electronic scientist.

Although the day of completely automatic control of automobiles is far off, Dr. Zworykin said, certain electronic devices to assist drivers in such matters as bad weather steering and collision prevention are nearer at hand.

To study the basic problems of automatic driving, Dr. Zworykin and his assistants have equipped a model five-foot car with electronic equipment. This laboratory car, which is powered by a storage battery, can:

1. Steer itself along a prescribed route.
2. Stop itself when approaching a metal obstruction.
3. Turn out of its original lane into a second lane as if to pass another car.

In the laboratory set-up, the model car is guided by a wire which represents a cable that would be laid in the roadbed of a superhighway. The wire sets up a magnetic field of a certain frequency which is picked up by the two coils, one on each side of the car. If one coil receives more of the signal than the other it means the car is no longer centered over the wire and electronic equipment controlling the steering wheel immediately brings the car back "on course."

To prevent a collision with an obstruction, simple transistor circuits associated with the guidance wire send out warning signals (of another frequency) whenever an obstruction passes or is stalled over them. When equipment in the model car receives the warning signal, the brakes are automatically applied and the car comes to a halt.

To simulate two lanes in the same direction, Dr. Zworykin has parallel guidance wires with a diagonal wire connecting them. When the model car senses the radio tail of an obstruction in the inner lane, its electronic equipment shunts it along the diagonal into the outer lane so as to pass the obstruction.

Discussing the trend toward modern highways on which driving is becoming both simple and tiresome, Dr. Zworykin said that "the time has arrived for consideration of automatic driving techniques which may relieve the driver of his routine duties whenever his car enters an express highway system.

Even now, with power steering, control devices are used to guide the car in preference to direct steering. Similarly, with power braking, the driver supplies a control signal rather than the physical force required to slow or stop the car. The automatic headlight dimmer is another device to take over a routine function of the driver.

The basic requirements of an automatic driving system harmonize with trends in modern highway construction. The requirements are that the roads have at least two lanes in each direction and that crossings and left turns across traffic be eliminated by cloverleafs and similar systems. With these conditions satisfied, the stage is set for a gradual introduction of measures to reduce traffic risks and simplify driving procedures.

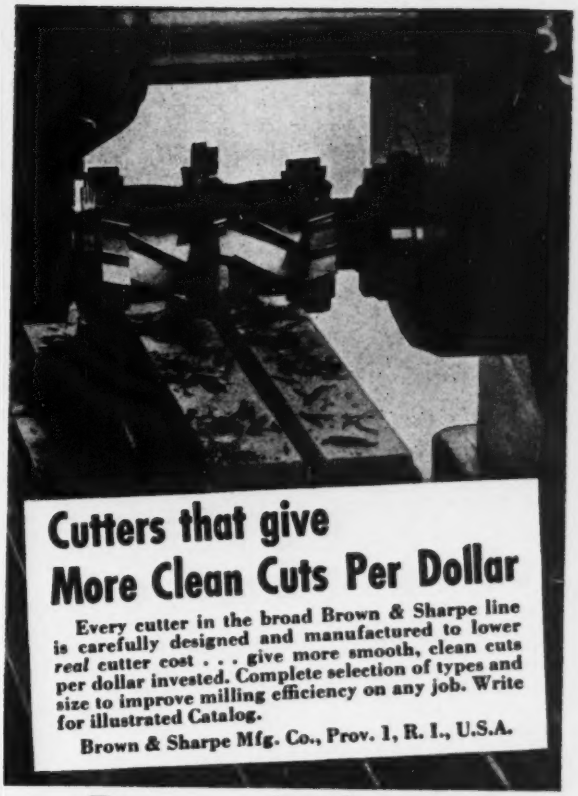
As a result of his research, Dr. Zworykin has drawn up a practical plan for the eventual installation of a completely automatic traffic system. This system also includes the automatic transportation of freight over long distances.

## LeSagian theory

*(Continued from page 30)*

plained by random short wave length electromagnetic rays existing in all space at a constant concentration.

The LeSagian Theory of Gravitation is not entirely useless. It is interesting, not only as an attempt to explain a mysterious property of matter, but as a method of solution for certain physical problems. As an explanation of the process of action at a distance, and not as an explanation for it, the theory is almost the same as Newton's Law of Gravitation, and is just as acceptable. In figure 6, a body is situated within a spherical shell of constant thickness and homogeneous material. With Newton's inverse square formula, it can be shown, with a little mathematical labor, that the body is not attracted to the side of the shell, no matter where inside it is located. With the LeSagian Theory, however, the same result is attained without any mathematics, and quite obviously. Consider those *ultramundane* streams going in any arbitrary antiparallel directions which pass through the body within the shell. Going in either direction, the intensity of the stream is decreased, upon passing through the shell, by the same amount, and the body behaves as though it were in free space. Two bodies within the shell would attract each other as in free space, but, according to the revised theory, with a slightly reduced gravitational constant. Such a spherical shell enclosing any system of bodies would, therefore, have no more effect than to change the constant of gravitation.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More Clean Cuts Per Dollar
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## biogeochemistry

*(Continued from page 37)*

A second limitation of the method is that the source of the trace elements in the soil need not have originated from an ore body immediately underneath. The parent deposit could be located miles away and the elements in the soil might have been transported over this distance by stream action.

In addition, the method is limited in its present form in that it can only effectively be used for finding zinc, copper, and cobalt. It has been shown by a series of tests in an area where the elements present underground were known that only copper and zinc anomalies correlate reasonably well with the presence of these elements below the surface. This is illustrated by some of the diagrams shown here. The diagrams also show the poor correlation of tin and cobalt deposits with the anomalies on the biogeochemical map.

Use of biogeochemical prospecting is also limited by a maximum burial of the ore of about 100 feet. Though this may at first appear to be a disadvantage, it actually is not because mining companies are only interested in finding ore deposits at shallow depths since mining costs increase with depth.

Despite its several limitations biogeochemistry has been successful in locating new mineral deposits. The accuracy of the method will almost certainly increase as more knowledge becomes available in this new science.

## SYNTHANE — making bigger payloads pay off

Synthane bushings, spacers, and bearings in the landing gear of this giant of the skies share the landing shock loads of twenty-five tons. But Synthane parts have many virtues in addition to their ability to withstand the jolts of heavy landings.

Parts made of this hard-working laminated plastic are unaffected by oils, and are dimensionally stable. They resist abrasion, and weigh half as much as aluminum.

Because Synthane is so easy to machine, it is appropriate for fair-leads and cable-sheaves in control systems. Because it is an excellent electrical insulator, you will find it at work in engine ignition systems, flight instruments, automatic controls, and radar sets. Because Synthane is light and corrosion-resistant, it's used for the flapper valves in fuel cell baffles.

Synthane has all these properties and many more. It might be a good material for you to try. Start by sending for the complete Synthane Catalog. Synthane Corporation, 42 River Road, Oaks, Penna.

### IS YOUR ANSWER HERE?

If you are not in the aircraft industry, Synthane's combination of properties may still stir your interest. Besides the properties at the left, Synthane has good tensile, compressive, flexural, impact and shear strength, a low coefficient of expansion, is moisture- and wear-resistant, easy to machine.

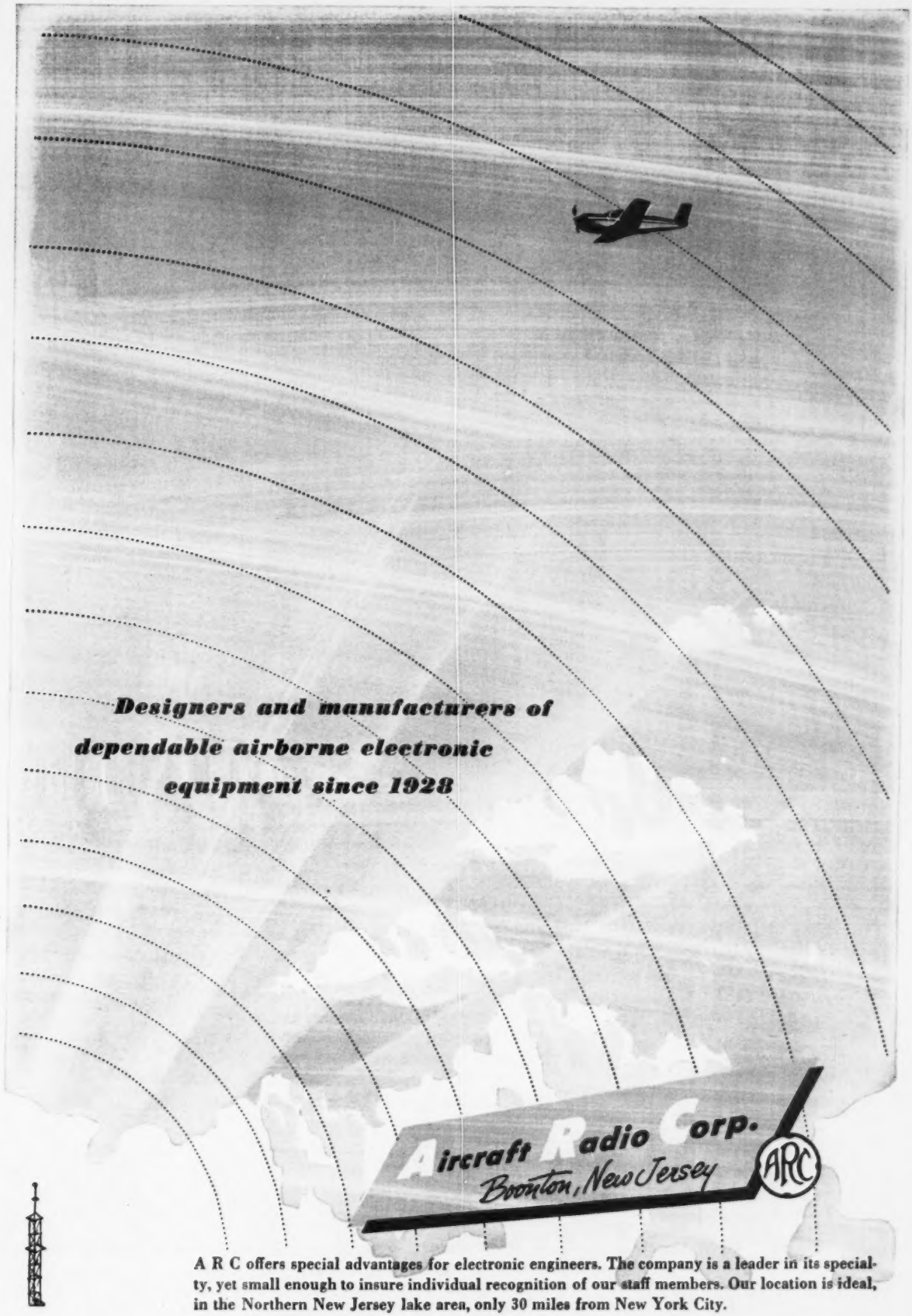
*Sliding component for handrail of moving stairway, machined from Synthane.*

*Breaker arms in distributor contain molded-laminated Synthane.*

*Synthane-one of industry's unseen essentials*

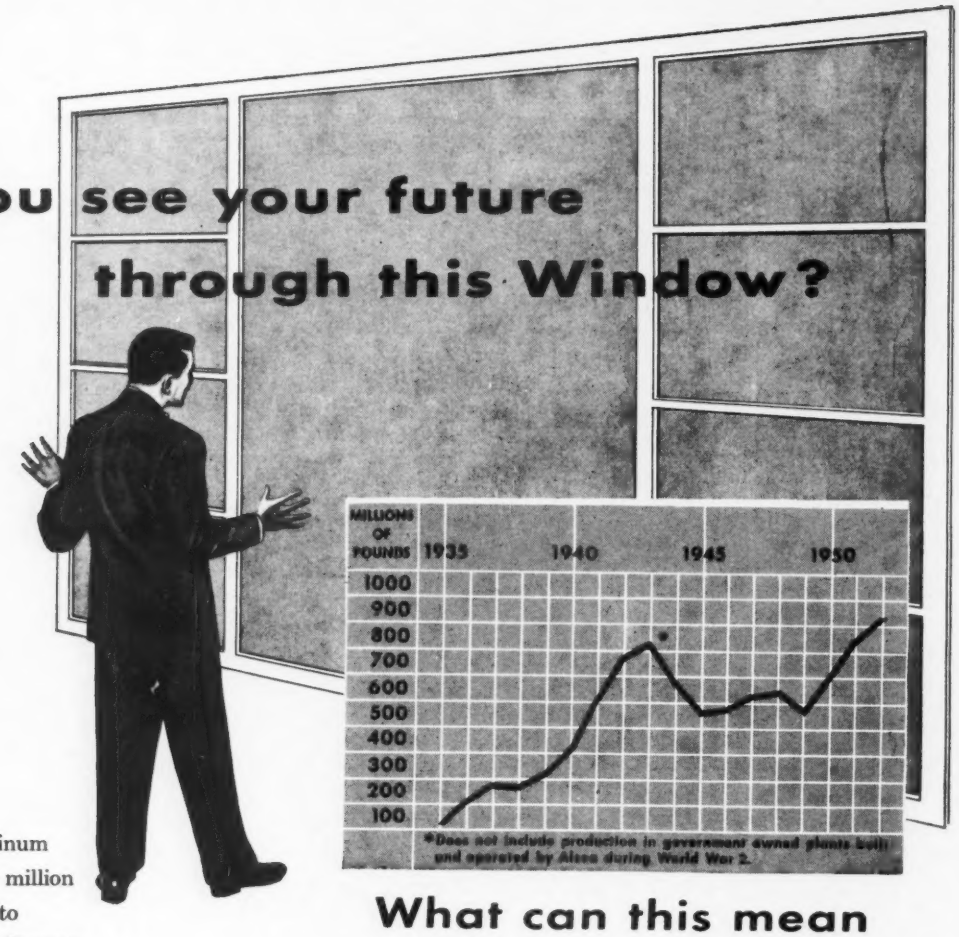
**SYNTHANE**

**LAMINATED PLASTICS**




A R C offers special advantages for electronic engineers. The company is a leader in its specialty, yet small enough to insure individual recognition of our staff members. Our location is ideal, in the Northern New Jersey lake area, only 30 miles from New York City.

# Can you see your future through this Window?




This is an aluminum window, one of four million that will go into buildings in 1953. Twenty years ago, it was just an idea in the mind of an Alcoa development engineer. Ten years ago, only a few thousand were made annually. Now, production *is increasing* at the rate of over half a million a year. This is just one of a torrent of new uses for aluminum which means that Alcoa must continue to expand. Consider the opportunities for you if you choose to grow with us.

## What can this mean as a career for you?

This is a production chart . . . shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1952. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve—is still rising, we're still expanding, and opportunities for young men joining us now are almost limitless.

Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places", get in touch with us. Benefits are many, stability is a matter of proud record, *opportunities are unlimited.*

For more facts, consult your Placement Director. ALUMINUM COMPANY OF AMERICA, Pittsburgh, Penna.

**Alcoa Aluminum**

ALUMINUM COMPANY OF AMERICA

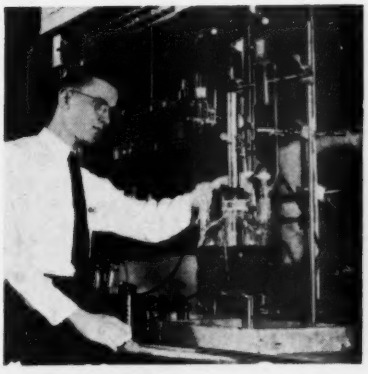
# THE DU PONT DIGEST

# *Research*

**provides broad opportunities for chemists, physicists and engineers cooperating on many problems.**

For one thing, much Du Pont research is fundamental, aimed at advancing scientific knowledge regardless of specific commercial objectives. However, such research often suggests new products . . . each with its own challenging technical problems which must be solved before commercial production can begin. Solving these problems offers another great field of work for teams of engineers and scientists.

"Teflon" tetrafluoroethylene resin is an example of this well integrated teamwork.



**Howard E. Holmquist,** *Ph.D. in Org. Chem., Univ. of Minn. '51, is shown at work on a problem in synthetic organic chemistry.*

**Doing chemical** *engineering research on a plate in a distillation tower are: C. M. Gamel, Jr., S.M.Ch.E., M.I.T. '48; and J. B. Jones, M.S.Ch.E., Univ. of Mich. '46.*

---

During research on refrigerants, the polymer was discovered and work was begun to make it useful. The new plastic had a remarkable combination of properties; temperature resistance beyond the range of any previous plastic, excellent electrical characteristics, and the highest degree of chemical inertness of any commercial plastic.

In fact, "Teflon" was almost too unusual. Although it melts, it is too viscous to flow like other plastics. It does not dissolve—even in aqua regia. There was no method for molding it or for making it into thin coatings.

The problem of molding was solved with the help of techniques used in powder metallurgy. "Teflon" is now molded by cold pressing, followed by sintering or "fusing" at about 360°C.

**Research workers** *have available modern apparatus, such as the infrared spectrometer being used here by Vaughan C. Chambers, Ph.D. Org. Chem., M.I.T. '50.*

For coatings, previous research suggested dispersions—minute particles suspended in a liquid. After much study, a team of technical men learned how to suspend particles of "Teflon" about 1/125,000 of an inch in diameter. Then a commercial scale process was devised. This development made possible thin coatings of "Teflon" and also a process for extruding the material.

Meanwhile, another group discovered how to successfully formulate the new plastic into "Teflon" tetrafluoroethylene resin finishes and wire enamels.

The development of "Teflon" illustrates the close teamwork that is the basis of research at Du Pont. But this teamwork doesn't end with research. Bringing the product to commercial reality requires development and design work by chemists and both chemical and mechanical engineers. Next month's Digest will feature information on the opportunities Du Pont offers men interested in this phase of making "better things for better living . . . through chemistry."

**ASK FOR "Chemical Engineers at Du Pont."** New illustrated booklet describes initial assignments, training and paths of promotion. Just send post card to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware. Also available: Du Pont and the College Graduate and Mechanical Engineers at Du Pont.

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

**Watch "Cavalcade of America," on Television**

# dormitory audio lines

By D. F. Shrader, '59

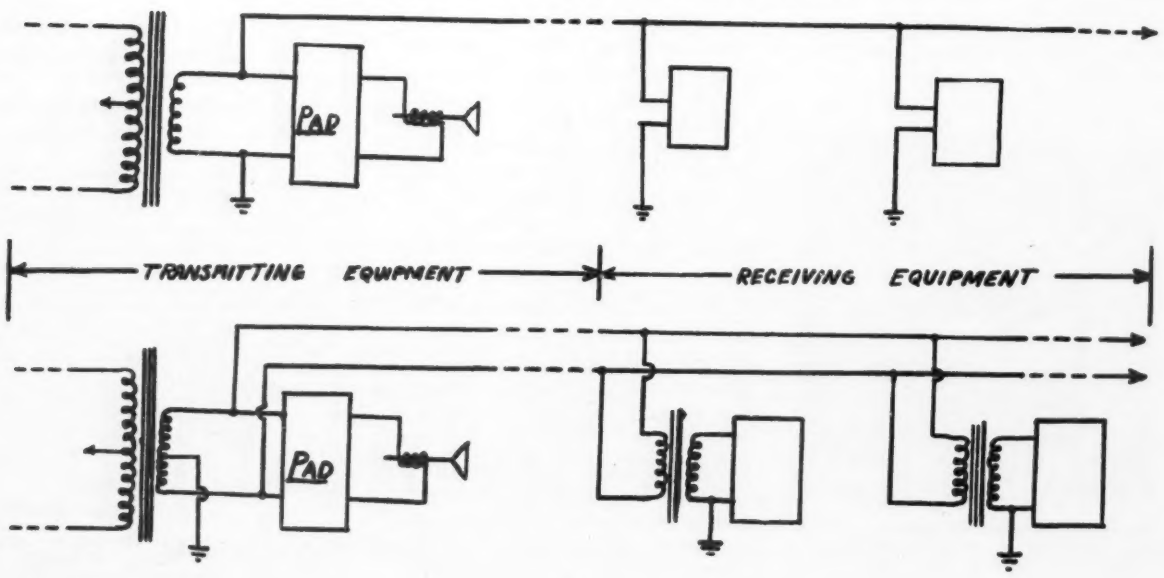
A natural desire of friends interested in music and owning record collections is to share them with one another. Three years ago two such students at M.I.T. solved the problem by installing wire between their rooms so that either one could listen to what the other was playing. Other students in this dormitory heard of this arrangement and asked that a wire be run to their rooms. Thus the dormitory audio line, known as the Runkle line after the dormitory of its origin, was born. In the second term of that year Phil Benkard, one of the two founders of the audio line, moved from Runkle to Bemis, and the first line over Ames Street was installed, bringing the services of the audio line to the residents of the Hayden and Bemis units. From these beginnings, the Runkle line has steadily grown. The original entrepreneurs and their somewhat primitive equipment (the original patch panel for the Runkle line consisted of a row of nails stuck in the door frame of Runkle 205; connections were made with clip leads) left and were replaced by others owning equipment of greater fidelity, and somewhat greater reliability.

Last year, the number of listeners to the Runkle line reached the figure of 150. The programming of the line featured the FM programs of WXHR, the concerts of the Boston Symphony and the Budapest String Quartet carried over WGBH, and other musical programs of special interest carried by other FM stations, especially the concerts of the Metropolitan Opera, the New York Philharmonic-Symphony Orchestra and the NBC Symphony Orchestra. When classical music was not available on FM, listeners to the Runkle line heard selections from various private record collections. Often, before finals or during the writing of term papers, music could be heard throughout the night.

Some students did not like the types of music played on the Runkle line, either by the student collectors or WXHR, so other lines sprang up, the largest being the "Pops" line. Generally, however, the line had the very excellent effect of broadening the listeners' musical interests especially in the fields of chamber and modern music. We have the report of the individual whose self-elected responsibility it was to tune in WXHR regularly that at one time he would turn down the speaker volume whenever music over his head was heard. Laziness sometimes prevented this and eventually, he even bought recorded Schoenberg and Couperin.

The technical background necessary to run au-

Unbalanced, line-to-ground system (top) and balanced system (below).



The record playing equipment at the Music Library.

dio lines is by no means large. Any Tech student able to understand Ohm's law and having a moderate amount of common sense should be able to operate such a system. Basically this consists merely of wiring the output of one audio amplifier to the input of another. The input impedance of most audio amplifiers is several orders of magnitude greater than the output or speaker impedance; so the feeding of the signal of one amplifier to many others does not impose any significant load on the originating amplifier.

The East Campus audio lines have in the past been operated on the simplest system possible, referred to as "line-to-ground." One wire could link all the amplifiers on the line; whoever was sending would connect this line to his output, and those receiving would connect it to their inputs. The amplifier chasses were all solidly grounded to the plumbing system, providing the return circuit. Necessary accessories for those sending were speaker pads to control the volume level in their rooms without affecting others', and a system of switching, using either plugs and jacks or toggle switches. In the case of individuals using several audio lines these systems could become quite complicated.

Experience showed that such an unbalanced line-to-ground system is unsatisfactory for long distances. Trouble was experienced from the beginning with the overhead line connecting the Senior House with the other East Campus dormitories. This line acted as a very efficient aerial; in fact, the pickup of WHDH on the line was often stronger than the audio signal which the line was supposed to be carrying. Various methods were tried to eliminate the rf signal, as well as hum pickup, but the overhead line was never really satisfactory.

Commercial radio and telephone audio lines are operated as "balanced lines". This requires a pair of wires for each line run. The audio voltages in each wire are equal in amplitude and opposite in phase, and the impedances between the wires and from each wire to ground are equal, generally 50 to 600 ohms. Any noise picked up by the line will appear as a voltage on each wire. These noise voltages will be equal in amplitude and in the same phase, and so will not appear across a load connected between the wires. The diagram below shows the difference between balanced and unbalanced systems somewhat more lucidly.

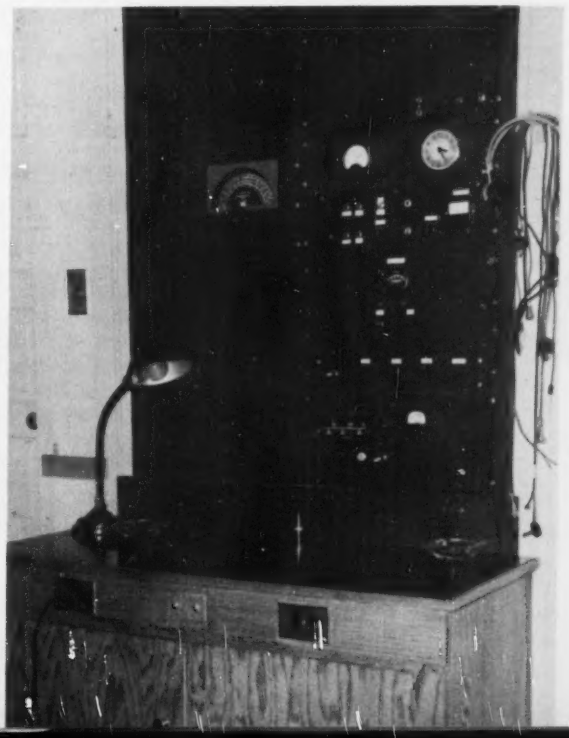
Balanced lines were used in the Runkle line in the very beginning, but were abandoned as the line was extended, since a balanced system requires a matching transformer at each point at which a signal is taken from or fed to the line. However, when the underground line between the Senior House and the other East Campus dormitories was installed last year, it became possible to operate a balanced system between these points. This was much more satisfactory than the former system.

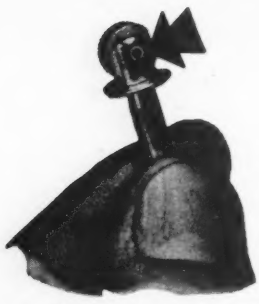
This past summer a number of students rented a Bell Telephone line from East Campus to the apartment of two students across the river. This line proved notably hum and noise free when operated as a balanced line, with transformers at each end. These transformers were specially built for the purpose by Mystic Transformers, although a number of commercially available line transformers could have been used. The line was operated at an impedance of 600 ohms, and an equalizer was inserted giving a 6 db./octave rise between 3000 and 15,000 cycles per second.

In addition to the extension of the Runkle line across the Charles River, two other innovations were put into effect this past summer. The first of these events was the first "live" program to be carried on the line. It seems that one of the residents of the apartment house to which the line across the river was run played the cello, and often had fellow members of a string quartet over to her apartment. One of the concerts by this group was featured on the line. The program included quartets by Boccherini, Mozart and Schubert; both the playing and the sound transmission to East Campus were quite enjoyable.

The second innovation was the carrying of the

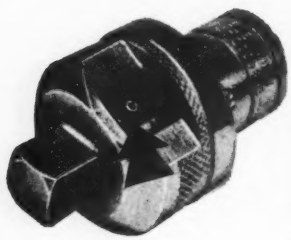
High-fidelity equipment of the type owned by several members of the Runkle line.



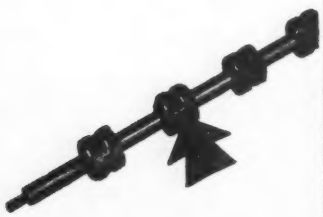


Replacing a rivet

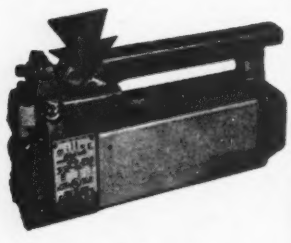
. . . a hinge pin



. . . a stop pin

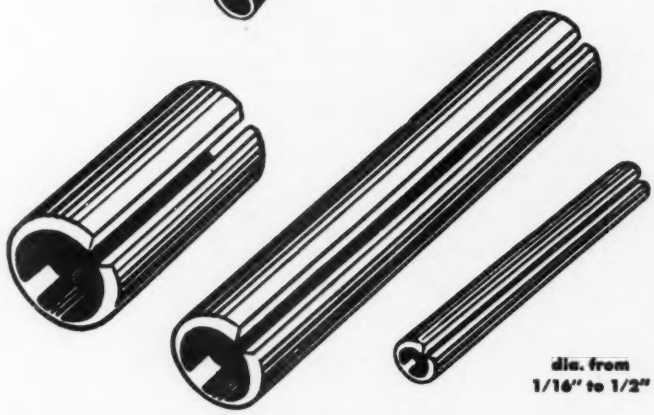


. . . a set screw



. . . a bolt and nut

ROLLPIN



dia. from 1/16" to 1/2"

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Rollpin is a hollow, split, cylindrically formed pin with chamfered ends. It is simply driven into holes drilled to normal production tolerances. Because Rollpin is slightly larger than standard sized holes, it compresses as inserted. It is self-locking—and vibration-proof—because of the constant pressure it exerts against hole walls. Its shear strength exceeds that of a cold rolled pin of the same diameter. Rollpin is readily removed with a drift or pin punch—and can be reused.

Because of its versatility—and the production economies it makes possible—Rollpin is finding wide usage in almost every phase of manufacturing activity. Write ror design information on the Rollpin. It will enable you to cut costs for many applications where use of rivets, set screws, dowels, and straight, serrated or cotter type pins create installation or performance problems.

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M.I.T. Music Library signal during the day by the Runkle line. A line had been installed by WMIT between their studios and the Music Library, in order that the music played during the day in the main listening room could be broadcast to the students. This line was tapped at Walker Memorial and run to the T.E.N. office, where it was sent over the line to East Campus and across the river.

With the beginning of the fall term and the resumption of WMIT's broadcasting, the question of continued availability of the Music Library signal was raised. WMIT, justly opposed to permitting individuals to tap its audio lines, has made available to the T.E.N. the output from a line amplifier, whose input in connected to the WMIT program line. Thus, listeners to the Runkle line during this coming term will be able to hear the signal from the Music Library during the day, as well as classical music programs of particular interest selected from WMIT's evening programming. WMIT is to be especially commended for allowing the T.E.N. to provide Runkle listeners with this service without the aural limitations of AM carrier-current broadcasting.

During the past year audio lines were formed in several of the dormitory units on the West Campus. It was felt that interconnection of these lines would be obviously beneficial to all concerned, and tentative plans were made to link the dormitory units by means of lines rented from Bell Telephone. However, it was clear that the equipment required to properly service these additional lines could not be provided by members of the Runkle line themselves. At the same time, it was felt that the flexibility and democracy of the line were the result of its lack of formal political organization, and that these virtues ought to be preserved. This dilemma was resolved when T.E.N. agreed to finance the additional equipment necessary to interconnect the dormitories, and to serve as a point of termination for the lines leading to the various dormitory units. The operation of the line within each dormitory unit would be under the complete control of the members of the line residing there.

The present plans of the members of the Runkle line are as follows: the operation of the line in East Campus will be the same as last year, with the exception that music from the music library and from the other dormitory units will be available over the balanced line system. The Runkle line will be extended to the dormitory units on West Campus as soon as groups of students are formed there. Each group will receive a balanced line which will interconnect them with the other dormitory units and with the music library.

Although the Runkle line has been in operation only three years, the enthusiastic support which it has attracted shows that it is providing a real service to the students of the East Campus dormitories. It is hoped that the planned extension of the line will provide similar pleasure to the many students who do not now have audio line service available. In fact any group of students off campus can enjoy the benefits of this service by renting a Bell wire pair to the T.E.N. office.

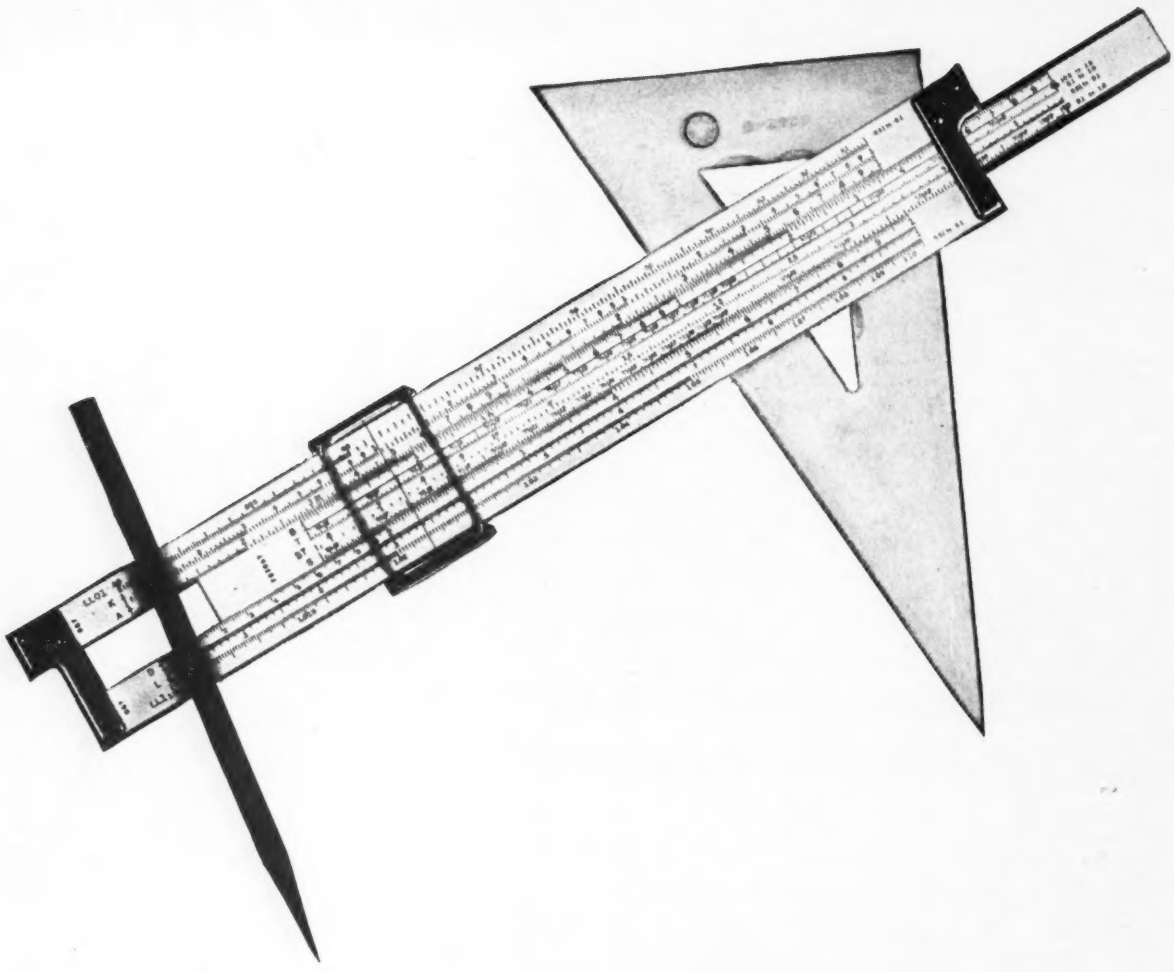
# education and the freshman

*(Continued from page 11)*

ously been good came tumbling down. All kinds of reasons are given for the downfall, the school is blamed, the curriculum is at fault, the students and faculty members have too narrow a viewpoint, without keeping in mind that his own habits and attitude have more influence on his effectiveness than anything else.

But what can a Tech student do to keep on a balanced intellectual diet, considering the demands of the curriculum and the habits of his friends? Obviously, it is impractical to be too different from one's colleagues, but if the whole climate of student opinion begins to change in the direction of maintaining pleasant conditions for learning to take place, the whole process is within the realm of possibility at any rate. No matter how busy one may be, there should be some time allowed every day for a few minutes of reading in fields other than one's own. One of the busiest physicians that ever lived in this country (later in England) was Sir William Osler. He solved this problem by the lifetime habit of reading, in some field far removed from medicine, fifteen minutes before going to bed. As a result, he was known as a classical scholar without peer in his profession. Furthermore, his effectiveness and interest in medicine was made much greater by his insight into how medicine fits into the life of people and how it is related to other fields of study. With the present availability of so many fine books at very low prices there is no reason why every first year man should not have his own private library of well written books with which he becomes familiar purely for the sheer enjoyment they bring.

In summary then, what should the Freshmen expect to accomplish during his undergraduate years at M.I.T. in order that he may look back upon those years with satisfaction? First and foremost he should expect to acquire the basic vocabulary with which to think clearly and concisely about material things and their relation to one another. This means proficiency in physics, mathematics, chemistry, biology and in the methods of science as well as their application. It means learning to read, write, speak and listen in order that there be free communication with others. He should expect to form a set of habits here that would set the tone of his living and thinking for the rest of his life. This means ability and skill in one area of knowledge and a moderate amount of ability to see the place of his own field in the general scheme of things. It means the development of interest, of enthusiasm, of a sense of purpose, in short, of maturity. Sidney Hook has commented that maturity connotes the habit of reasonable expectation, rather than reliance on wishful thinking. The intellectually mature man has great respect for but not a worship of facts. The man who completes his four years at the Institute knows that he knows very little, or should know it, while his real accomplishments reside in the fact that he has obtained the will to learn, to serve, to exercise humility and to try to understand. Education as well as maturity are ideals worthy of a lifetime search for them.



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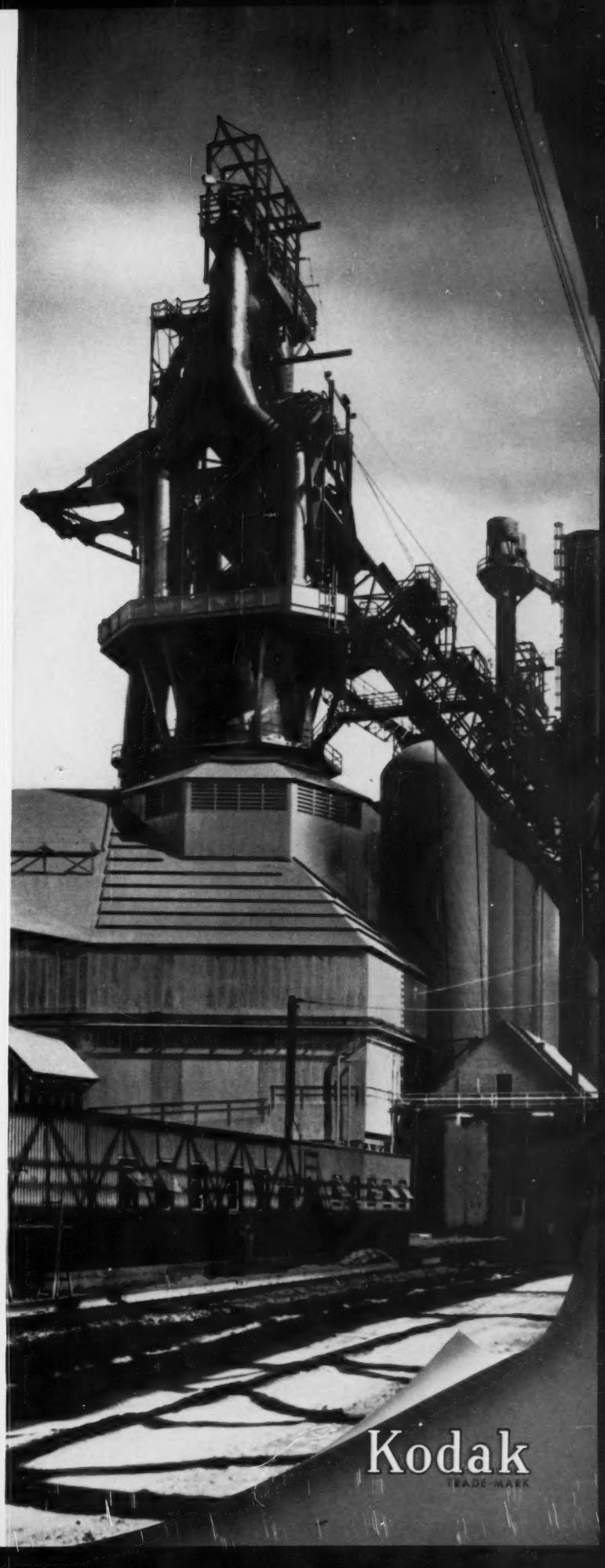

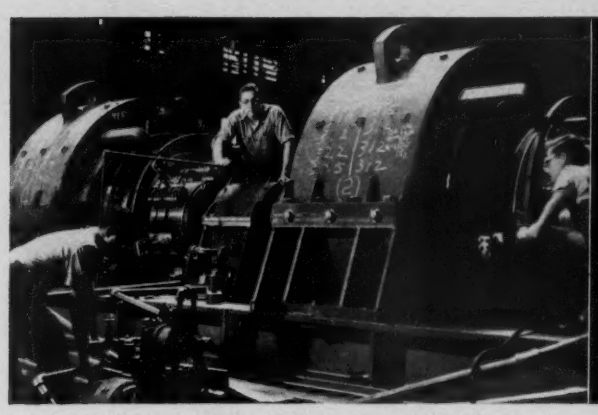

CHARLES SNYDER, R.P.I., (center) adjusting 5250 triple-unit d-c mill motor for use in a steel mill.

Engineers RICHARD RENK, IOWA STATE, (left) and ALLEN FRINK, CATHOLIC UNIV., make last-minute check on 1600-hp diesel-electric switcher before it is moved to test track.

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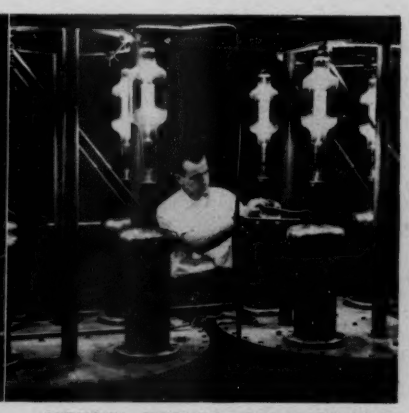
Test engineers E. K. VON FANGE, U. OF NEB., (left) and R. E. LOVE, U. OF TEXAS, work on stacker and stapler built by them for homework project.

Physicist ROGER DEWES, BROOKLYN POLY., working with scintillation counter in G.E.'s Engineering Laboratory.



ANTHONY TERZANO, PRATT INSTITUTE, checks connections on direct-current rectifier which charges 7,500,000-volt impulse generator in G.E.'s new High-voltage Laboratory.

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